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ABSTRACT

This guide is designed to help teachers in automotive technician programs for grades 11 and 12 teach the critical competencies of the program. The critical competencies covered are the Priority 1 competencies in Ohio Occupational Competency Assessment Profile (OCAP) for Automotive Technician. Teacher materials include program/instructor resources, program basics, additional program elements, and activity options. Units 1-8 cover the following areas (with number of Priority 1 competencies in parentheses): engine repair (11); automatic transmission and transaxle (11); manual drive train and axles (5); suspension and steering (11); brakes (15); electrical/electronic systems (14); heating and air conditioning (11); and engine performance (23). Units 9 and 10 cover basic shop and safety practices (5) and preventive maintenance (1). The Competency Development Guides (CDGs) are designed to provide suggestions for how to teach the units and competencies. Each CDG covers one competency (or two or more related competencies) and includes the following information: unit, subunit, and competency number and title; objective; introduction; references; presentation (content outline with key points); review questions; application (student activities); and evaluation (Performance Checklist with directions for use). (YLB)

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Auto Technician:
An Instructional Guide for Teachers

Instruction Tied to the Task List
of the
National Automotive Technicians Education Foundation (NATEF)
for
Automotive Service Excellence (ASE) Certification

1998

Additional copies of this guide are available from—
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1900 Kenny Road
Columbus, Ohio 43210-1090
614-292-4277 or
800-848-4815, ext. 2-4277

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State of Ohio
Department of Education

John M. Goff
Superintendent of Public Instruction

Vocational and Adult Education
Joanna Kister, Director, 65 South Front Street, Room 907, Columbus 43215-4183

June 2, 1998

To All Automotive Technology Instructors:

It is with great pleasure that we are able to introduce to you, *Auto Technician: An Instructional Guide for Teachers*. This guide represents a significant investment of time and effort and is intended to assist you in becoming better instructors and improving the learning experiences of your students.

You should find this document to be very useful in the planning and delivery of your everyday instruction. We can say this because it was developed by Ohio automotive technology instructors. We feel confident that your colleagues—those who know best what is needed to do the job, what your concerns are, and how they might be addressed—have designed a guide that is full of the kind of information you want. It is also safe to claim that because these instructors were so influential in the design of the document, its connection to the OCAP and ASE competencies is solid and should keep you on target in teaching what is necessary.

We hope you will use the guide routinely in your program. If you do, we are sure you will find it to be the most valuable resource on your bookshelf. If used appropriately, you should see improvement in the overall operation of your program, which will ultimately translate into improved student performance.

Sincerely,

Bob Bowermeister

Bob Bowermeister, Assistant Director
Trade and Industrial/Health Occupations
The Division of Vocational and Adult Education

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Vocational Instructional Materials Laboratory Staff

- Deborah Bingham Catri, Director
- Joyce Leimbach, Research Specialist; coordinator of the early phases of the guide's development
- Lois G. Harrington, Senior Program Associate; coordinator of the guide's review and revision

Ohio Department of Education, Division of Vocational and Adult Education

- Robert Bowermeister, Assistant Director, Trade and Industrial Education
- James Wiblin, former assistant director, Trade and Industrial Education
- Robert Shobe, Educational Consultant, Springfield, Ohio
- Richard Wancho, Supervisor, Trade and Industrial Education

Central Ohio Vocational Education Personnel Development Center

- Gayl Ray, Teacher Educator

ASE-Certified Automotive Technician Instructors in Ohio

- James Anderson, Greenville High School, Greenville, Ohio
- Keith Boothe, Miami Valley CTC, Clayton, Ohio
- A. J. Caudill, Springfield-Clark County JVS, Springfield, Ohio
- Larry Dixon, Licking County JVS, Newark, Ohio
- Paul Kruthaup, Whitmer CTC, Toledo, Ohio
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- Michael Rehner, Northwest Career Center, Columbus, Ohio
- Ronald Rofe, Ohio Hi-Point Career Center, Bellfontaine, Ohio
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The following chart shows the order in which the Competency Development Guides (CDGs) are presented, as well as what competency or clustered competencies each CDG covers. Unit, subunit, and competency numbers refer to the numbers assigned to the NATEF task list components in Ohio's 1996 Occupational Competency Assessment Profile (OCAP) for *Automotive Technician*.

Please note that where a CDG covers competencies from two or more units, identical copies of that CDG are placed within ***each*** of those units. Teachers in local programs will need to decide in which unit it will be given primary emphasis (or in which initial instruction will occur).

Units	Subunits	Competencies
1 & 8	1.1 & 8.1	1.1.1 & 8.1.1 Interpret and verify complaint; determine needed repairs
1	1.1	1.1.5 Perform engine vacuum tests; determine needed repairs
1 & 8	1.1 & 8.1	1.1.6 & 8.1.6 Perform cylinder power balance tests; determine needed repairs
1 & 8	1.1 & 8.1	1.1.7 & 8.1.7 Perform cylinder compression tests; determine needed repairs
1 & 8	1.1 & 8.1	1.1.8 & 8.1.8 Perform cylinder leakage tests; determine needed repairs
1 & 8	1.2 & 8.11	1.2.13 & 8.11.1 Adjust valves on engines with mechanical or hydraulic lifters
1	1.3	1.3.3 Inspect internal and external threads; repair as needed
1	1.3	1.3.18 Prime engine lubrication system
1, 7 & 8	1.4, 7.4 & 8.11	1.4.3, 7.4.2, 8.11.3 & 8.11.4 Perform cooling system tests (pressure, combustion leakage, and temperature); determine needed repairs Perform cooling system, cap, and recovery system tests (pressure, combustion leakage, and temperature); determine needed repairs Verify engine operating temperature; determine needed action Perform cooling system pressure tests; check coolant condition; inspect and test radiator, pressure cap, coolant recovery tank, and hoses; service or replace as needed
1	1.4	1.4.4 Inspect, replace, and adjust drive belts and pulleys
1	1.4	1.4.14 Perform oil and filter change
2	2.1	2.1.1 Interpret and verify driver's complaint; verify proper engine operation; determine needed repairs
2	2.1	2.1.2 Diagnose unusual fluid usage, level, and condition problems; determine needed repairs
2	2.1	2.1.3 Perform pressure tests; determine needed repairs

Units	Subunits	Competencies
2	2.2	2.2.1 Inspect, adjust or replace manual shift valve and throttle (TV) linkages or cables and check gear select indicator (as applicable)
2	2.2	2.2.2 Service transmission; perform visual inspection; replace fluids and filters
2	2.3	2.3.5 Inspect, leak test, flush, and replace cooler, lines, and fittings
2	2.4	2.4.3 Disassemble, clean, and inspect transmission/transaxle
2	2.4	2.4.4 Assemble transmission/transaxle
2	2.5	2.5.4 Check torque converter and transmission cooling system for contamination
2	2.7	2.7.2 Measure clutch pack clearance; adjust as needed
2	2.7	2.7.3 Air test operation of clutch and servo assemblies
3	3.1	3.1.1 Diagnose clutch noise, binding, slippage, pulsation, and chatter problems; determine needed repairs
3	3.1	3.1.2 Inspect, adjust or replace clutch pedal linkage, cables, automatic adjuster mechanisms, brackets, bushings, pivots, and springs
3	3.1	3.1.3 Inspect, adjust, repair or replace hydraulic clutch slave and master cylinders, lines, and hoses
3	3.2 & 3.3	3.2.1 & 3.3.1 Diagnose transmission/transaxle noise, hard shifting, jumping out of gear, and fluid leakage problems; determine needed repairs
4	4.1	4.1.1 Disable supplemental restraint systems (SRS)
4	4.1	4.1.11 Inspect manual and power steering fluid levels and condition
4	4.1	4.1.14 Inspect, replace, and adjust power steering pump belt
4	4.2	4.2.11 Remove, inspect, and replace MacPherson strut cartridge or assembly, strut coil spring, insulators, and upper strut bearing mount
4 & 5	4.4 & 5.5	4.4.2, 5.5.2 & 5.5.7 Remove, inspect, and service or replace front and rear wheel bearings Remove, clean, inspect, repack, and reinstall wheel bearings and replace seals; reinstall hub and adjust wheel bearings Replace wheel bearing and race

Units	Subunits	Competencies
4	4.5	4.5.1 Diagnose vehicle wander, drift, pull, hard steering, bump steer, memory steer, torque steer, and steering return problems; determine needed repairs
4	4.6	4.6.1 Diagnose tire wear patterns; determine needed repairs
4	4.6	4.6.2 Inspect tires; check and adjust air pressure
4	4.6	4.6.4 & 4.6.9 Rotate tires; reinstall wheels; torque lug nuts
4	4.6	4.6.7 Balance wheel and tire assembly (static and dynamic)
5	5.1	5.1.4 Diagnose poor stopping, pulling, or dragging caused by problems in the hydraulic system; ; determine needed repairs
5	5.1	5.1.8 Select, handle, store, and install brake fluids
5	5.1	5.1.12 Bleed (manual, pressure, vacuum, or surge) brake system; flush hydraulic system
5	5.2 & 5.3	5.2.1 & 5.3.1 Diagnose poor stopping, noise, pulling, grabbing, dragging, or pedal pulsation problems; determine needed repairs
5	5.2	5.2.2 Remove, clean (using proper safety procedures), inspect, and measure brake drums; service or replace as needed
5	5.2 & 5.3	5.2.7 & 5.3.11 Reinstall wheel, torque lug nuts, and make final checks and adjustments
5	5.3	5.3.7 Clean, inspect, and measure rotor with a dial indicator and a micrometer; determine need to machine or replace
5	5.3	5.3.10 Fill master cylinder with recommended fluid, and seat pads; inspect caliper for leaks
5	5.5	5.5.1 Diagnose wheel bearing noises, wheel shimmy, and vibration problems; determine needed repairs
4 & 5	4.4 & 5.5	4.4.2, 5.5.2 & 5.5.7 Remove, inspect, and service or replace front and rear wheel bearings Remove, clean, inspect, repack, and reinstall wheel bearings and replace seals; reinstall hub and adjust wheel bearings Replace wheel bearing and race
5	5.5	5.5.4 Check parking brake operation; adjust as needed
5	5.5	5.5.6 Check operation of brake stop light system; adjust and service as needed

Units	Subunits	Competencies
6	6.1	6.1.1 Use wiring diagrams during diagnosis of electrical circuit problems
6 & 8	6.1 & 8.2	6.1.3 & 8.2.5 Check voltage and voltage drop in electrical/electronic circuits using a digital multimeter (DMM); determine needed repairs Obtain and interpret digital multimeter (DMM) readings
6	6.1	6.1.4 Check current flow in electrical/electronic circuits and components using an ammeter; determine needed repairs
6 & 8	6.1 & 8.2	6.1.6 & 8.2.8 Find shorts, grounds, opens, and resistance problems in electrical/electronic circuits; determine needed repairs Inspect and test power and ground circuits and connections; service or replace as needed
6	6.1	6.1.7 Measure and diagnose the cause(s) of abnormal key-off battery drain; determine needed repairs
6	6.1	6.1.8 Inspect and test fusible links, circuit breakers and fuses; replace as needed
6	6.1	6.1.9 Inspect and test switches, connectors, relays, and wires of electrical/electronic circuits; repair or replace as needed
6	6.2	6.2.1 Perform battery state-of-charge test; determine needed service
6	6.2	6.2.2 Perform battery capacity (load, high-rate discharge) test; determine needed service
6	6.2	6.2.6 Inspect and clean battery cables, connectors, clamps, and hold-downs; repair or replace as needed
6	6.2	6.2.7 Start a vehicle using jumper cables and a battery or auxiliary power supply
6	6.3	6.3.1 Perform starter current draw and circuit voltage drop test; determine needed repairs
6	6.4	6.4.1 Diagnose charging system problems that cause an undercharge, a no-charge, or an overcharge condition
6	6.4	6.4.2 Inspect and adjust alternator drive belts; replace as needed

Units	Subunits	Competencies
1, 7 & 8	1.4, 7.4 & 8.11	1.4.3, 7.4.2, 8.11.3 & 8.11.4 Perform cooling system tests (pressure, combustion leakage, and temperature); determine needed repairs Perform cooling system, cap, and recovery system tests (pressure, combustion leakage, and temperature); determine needed repairs Verify engine operating temperature; determine needed action Perform cooling system pressure tests; check coolant condition; inspect and test radiator, pressure cap, coolant recovery tank, and hoses; service or replace as needed
7	7.4	7.4.3 Inspect engine cooling and heater system hoses and belts; replace as needed
7 & 8	7.4 & 8.11	7.4.4 & 8.11.5 Inspect and test thermostat, by-pass, and housing; replace as needed
7	7.4	7.4.5 Determine coolant condition; drain and recover
7	7.4	7.4.6 Flush system and refill with recommended coolant; bleed system
7	7.8	7.8.1 Verify correct operation and maintenance of refrigerant handling equipment
7	7.8	7.8.2 Identify and recover A/C system refrigerant
7	7.8	7.8.3 Recycle refrigerant
7	7.8	7.8.4 Label and store refrigerant
7	7.8	7.8.5 Test recycled refrigerant for non-condensable gases
7	7.8	7.8.6 Evacuate and charge A/C system
1 & 8	1.1 & 8.1	1.1.1 & 8.1.1 Interpret and verify complaint; determine needed repairs
8	8.1	8.1.5 Perform engine absolute (vacuum/boost) manifold pressure tests; determine needed repairs
1 & 8	1.1 & 8.1	1.1.6 & 8.1.6 Perform cylinder power balance tests; determine needed repairs
1 & 8	1.1 & 8.1	1.1.7 & 8.1.7 Perform cylinder compression tests; determine needed repairs
1 & 8	1.1 & 8.1	1.1.8 & 8.1.8 Perform cylinder leakage tests; determine needed repairs
8	8.1	8.1.9 Diagnose engine mechanical, electrical, electronic, fuel, and ignition problems with an oscilloscope and engine diagnostic equipment; determine needed action

Units	Subunits	Competencies
8	8.1	8.1.10 Prepare 4- and 5-gas analyzer; inspect and prepare vehicle for test and obtain exhaust readings; interpret readings and determine needed action
8	8.2	8.2.2 Retrieve and record stored diagnostic trouble codes
6 & 8	6.1 & 8.2	6.1.3 & 8.2.5 Check voltage and voltage drop in electrical/electronic circuits using a digital multimeter (DMM); determine needed repairs Obtain and interpret digital multimeter (DMM) readings
8	8.2	8.2.7 Locate and interpret vehicle and major component identification numbers (VIN, vehicle certification labels and calibration decals)
6 & 8	6.1 & 8.2	6.1.6 & 8.2.8 Find shorts, grounds, opens, and resistance problems in electrical/electronic circuits; determine needed repairs Inspect and test power and ground circuits and connections; service or replace as needed
8	8.3	8.3.1 & 8.3.2 Diagnose no-starting, driveability, and emissions problems on vehicles with electronic ignition (distributorless) and distributor ignition (DI) systems; determine needed repairs
8	8.3	8.3.7 Check and adjust (where applicable) ignition system timing and timing advance/retard
8	8.4	8.4.2 Diagnose hot or cold no-starting, hard starting, poor driveability, incorrect idle speed, poor idle, flooding, hesitation, surging, engine misfire, power loss, stalling, poor mileage, dieseling, and emissions problems on vehicles with injection-type fuel systems; determine needed action
8	8.4	8.4.6 Replace fuel filters
8	8.5	8.5.1 Diagnose oil leaks, emissions and driveability problems resulting from failure of the positive crankcase ventilation (PCV) system
8	8.6	8.6.1 Diagnose emissions and driveability problems caused by failure of the exhaust gas recirculation (EGR) system
1 & 8	1.2 & 8.11	1.2.13 & 8.11.1 Adjust valves on engines with mechanical or hydraulic lifters
8	8.11	8.11.2 Verify correct camshaft timing; determine needed action

Units	Subunits	Competencies
1, 7 & 8	1.4, 7.4 & 8.11	1.4.3, 7.4.2, 8.11.3 & 8.11.4 Perform cooling system tests (pressure, combustion leakage, and temperature); determine needed repairs Perform cooling system, cap, and recovery system tests (pressure, combustion leakage, and temperature); determine needed repairs Verify engine operating temperature; determine needed action Perform cooling system pressure tests; check coolant condition; inspect and test radiator, pressure cap, coolant recovery tank, and hoses; service or replace as needed
7 & 8	7.4 & 8.11	7.4.4 & 8.11.5 Inspect and test thermostat, by-pass, and housing; replace as needed
9		9.1 Utilize personal safety equipment
9		9.2 Respond to fire situations
9		9.3 Demonstrate general safety practices
9		9.4 Maintain safe work environment
9		9.5 Access needed information using available references and resources
9		9.6 Demonstrate use of basic tools
9		9.7 Provide customer service
9		9.8 Acquire parts
10		10.2 Inspect vehicle components and systems

Insert the
"About This Guide"
Tab Here

Overview

This guide is designed to help you, as a teacher in an Automotive Technician program, to teach the critical competencies of the program. The guide does not cover ***all*** the content of the program. Local conditions within the district and the employment community will determine the full program content. It is hoped, however, that the structure of the Competency Development Guides (CDGs) in this document will provide you with a model you can use in developing the additional lesson guides you need for your particular program.

Additional teacher-made plans and handouts, related articles, etc., can all be added to this binder. Ultimately, we hope, it will provide you with an instructional guide that is truly ***yours***—one that closely fits your program's structure and your instructional needs.

What Is Covered

The "critical" competencies covered in the guide are the Priority 1 competencies in the Occupational Competency Analysis Profile (OCAP) for *Automotive Technician*.

The technical competencies in the first eight units of the OCAP come directly from the 1996 *ASE Program Certification Standards for Automobile Technician Training Programs*. These units cover the following areas:

Unit	Instructional Focus	# of Priority 1 Competencies
1	Engine Repair	11
2	Automatic Transmission and Transaxle	11
3	Manual Drive Train and Axles	5
4	Suspension and Steering	11
5	Brakes	15
6	Electrical/Electronic Systems	14
7	Heating and Air Conditioning	11
8	Engine Performance	23

The technical competencies in the final units of the OCAP were identified by a panel of expert automotive technicians as important to the success of entry-level automotive technicians in Ohio. These units cover the following areas:

Unit	Instructional Focus	# of Priority 1 Competencies*
9	Basic Shop and Safety Practices	5 (P-1) + 3 (P-2)
10	Preventive Maintenance	1

* Because safety is probably the most critical area for students to master, both Priority 1 and Priority 2 competencies are included for Unit 9.

These competencies tell ***what*** critical skills should be taught.

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Program Organization

The next question is ***when***—and in what order—these units and competencies should be taught. The following chart shows one logical approach for organizing the Automotive Technician program. The exact way in which your program is organized will, however, depend on your local situation (number of teachers in program, availability of equipment, opportunity for teachers in other specialties such as welding and electronics to teach parts of the program, etc.).

Unit	Instructional Focus	Teaching Time*
9	Basic Shop and Safety Practices	Junior Year
10	Preventive Maintenance	Junior Year
6	Electrical/Electronic Systems	Junior Year
1	Engine Repair	Junior Year
5	Brakes	Junior Year
7	Heating	Junior Year
8	Engine Performance	Junior/Senior Year
4	Suspension and Steering	Senior Year
2	Automatic Transmission and Transaxle	Senior Year
3	Manual Drive Train and Axles	Senior Year
7	Air Conditioning	Senior Year

* Once introduced, competencies should be ***reinforced*** throughout the remainder of the two-year curriculum.

It is recommended that the majority of instruction should be presented from simple to complex. However, there are times when you must take advantage of a teachable moment. If during a troubleshooting process, for example, an unrelated problem is noted and there is high student interest in that problem, it may make sense to address the unrelated problem at that time. On-the-job training is a valuable tool in the auto technician industry.

Using the Competency Development Guides (CDGs)

The CDGs in this guide are designed to provide suggestions for ***how*** to teach the units and competencies. Each CDG covers one competency (or two or more related competencies) and includes the following information:

- ***Unit, subunit, and competency number and title***—These statements come directly from the ASE-based Occupational Competency Analysis Profile (OCAP) for *Automotive Technician*.
- ***Objective***—Identifies the skill to be performed for evaluation, the conditions under which the skill is to be performed, and the criteria for evaluating competence.
- ***Introduction***—Provides suggestions for ways to motivate students and spark their interest in learning the competency.
- ***References***—Suggests resources that could be used to support the lesson (e.g., technical service bulletins, preventive maintenance guides, written text materials, and/or audiovisual technical information).
- ***Presentation***—Outlines content to be covered related to the competency, including key points that need to be emphasized and ideas for related academic instruction.

- ***Review questions***—Provides sample questions that can be used to provoke student thought and help you determine whether students understand the information presented.
- ***Application***—Suggests activities in which students can apply the knowledge and practice the skills learned in the lesson. Ideally, these activities require critical thinking, decision making, and problem solving and prepare students for final instructor evaluation.
- ***Evaluation***—Provides standard directions for instructor assessment using the Performance Checklist that follows each CDG.

Notice that the above description keeps saying "suggests." These lessons are not set in stone. They are designed to outline for instructors (particularly new instructors) what must be covered and to give some suggestions of how to teach that content in a motivational way, with a high level of student involvement. But the good teacher will add to these plans based on a number of factors:

- Needs, interests, and abilities of the students
- Specific tools and equipment used in the program
- His/her own personal teaching style

For example, although the practice activities included in each CDG were designed to fit the lesson content, other activities could fit the content just as well. In "Activity Options," pp. 25–28, you will find examples of the different types of activities suggested in the CDGs. Feel free to make use of any of these activities in any lesson. Simply modify the activity to fit the lesson content. Likewise, feel free to develop your own practice activities.

Each CDG is generic—it talks about skills in general, without reference to particular equipment or models of cars. To add specificity to the plan, you can develop a procedure sheet (or lab guide) for each competency, using the CDG as a guide. This sheet—also designed for student use during practice—would fit the specific equipment, tools, materials, and supplies used in your learning laboratory.

Program/Instructor Resources

Advisory Committee

Each program needs to maintain a functioning advisory (or craft) committee made up of individuals from the local area who are current with the technology and who maintain ASE certification. The committee membership may include former graduates, manufacturer's representatives, automotive technicians, service managers/service directors, supervisory personnel, or others who are genuinely interested in helping to build and maintain a successful Automotive Technician program.

This committee's role is to act in an advisory capacity, assisting with development of the instructional program, providing on-the-job experiences, and sharing expertise in specialized techniques and information regarding new products or procedures used in the industry.

Sources of Materials and Equipment

Each school needs to provide sufficient fiscal resources to support an up-to-date program. However, program resources can be enhanced via outside support and donations, particularly with the assistance of advisory committee members. For example:

- Complimentary or loaner copies of educational videos can be obtained from local vehicle dealers, parts houses, and the Bureau of Worker's Compensation video library.
- Retail service centers (e.g., Goodyear, Firestone), car dealers, salvage yards, and parts houses may be glad to contribute worn or damaged parts (e.g., rotors, drums, exhaust equipment) or even engines.
- Members of the public sometimes donate cars with salvageable parts to the school for tax purposes. (Cautions: Make sure the title is free and clear, with no liens. Have the car's owner estimate the car's value and file the form with the IRS so responsibility for the estimate is theirs, not yours.)
- Vehicle donations and other forms of support can also come from building good relationships with individual car manufacturers or dealers—or, even better with a Dealer's Association or Automotive Service Association, with links to many firms and agencies.
- When community college automotive programs get new equipment, they may be willing to donate their older equipment to the secondary school programs that send them students.

Program support can also be enhanced by applying for state funds (e.g., mini-grants, matching funds).

Sources of Technical Assistance

It is important to build and maintain an up-to-date list of addresses/phone numbers of manufacturer's representatives and others who can provide technical assistance, technical bulletin updates, continuing education information, and other information needed to maintain an exemplary program.

At one time, this address list would contain only post office addresses, but today it should also include URLs: the addresses of Websites on the Internet. For example, Gates Rubber Company has a Webpage that includes an illustrated info/procedure sheet on using the "squeeze test" to detect a bad hose. Such a sheet could be printed and handed out to students. The address of the Gates site is <www.gates.com>. Valvoline also has a Website <www.valvoline.com> with a link to ASE and an EXPERT'S CORNER. A search of the Internet for other manufacturers could yield much useful information.

Potentially useful Websites have been created by corporations, foundations, associations, publishers, individuals, and other entities focusing on automotive information. A few examples follow.

The National Automotive Technicians Education Foundation (NATEF) has a Website where you can locate (and download) the automobile program standards or related applied academics, get information on what's new, check out career information and upcoming events, or locate ASE-certified programs (and contact people) around the country.

NATEF 13505 Dulles Technology Drive, Suite 2 Herndon, VA 20171-3421	Phone: 703-713-0100 Fax: 703-713-3919 Website: www.natef.org

ALLDATA Corporation's Website includes a PROFESSIONAL SITE that offers free services to all automotive repair professionals who register.

ALLDATA Corporation 9412 Big Horn Boulevard Elk Grove, CA 95758	Phone: 916-684-5200 Toll-Free: 800-829-8727 Fax: 916-684-5225 Website: www.alldata.com

The International Automotive Technicians' Network (IATN) includes professional automotive technicians from around the world, and IATN's Website provides a forum for members to exchange technical knowledge and information through discussion groups and live conferences. Any Professional Automotive Technician with a minimum of 4 years of full-time work experience is eligible to join. Teachers in Ohio who belong to IATN indicate that this is an excellent forum for getting help or answers to questions when needed—with a very short turnaround time.

IATN	Website: www.iatn.net

MOTOR Magazine—a source of automotive service and repair information—is available online, with a searchable database of articles and features from the print version of the magazine. The site also provides an ON-LINE SOURCE GUIDE that lets you search directories of products & suppliers, manufacturers, technical hotlines for professional mechanics, program jobbers, and training classes and materials.

MOTOR Magazine On-line	Website: www.motor.com/magazine.htm

Delmar Publishers—a major publisher of automotive education resources for students, instructors, and professionals—has a Website called autoed.com. In addition to detailed information about available publications, the site offers an INSTRUCTOR DISCUSSION FORUM where instructors can post comments and access relevant auto industry news items for discussion. The site also offers numerous links to other relevant sites, including links to specific auto manufacturers (American, European, Japanese/Korean) and sites providing auto technology and repair information.

Delmar Publishers P.O. Box 15015 Albany, NY 12212	Toll-Free: Website: E-mail:	800-865-5840 www.autoed.com info@delmar.com

AUTOSHOP–Online provides expert advice on auto repair, maintenance, and operation. A staff of certified technicians in the SERVICE DEPARTMENT offer interactive diagnostics and advice to consumers for $29.95/issue addressed. AUTOMOTIVE 101 is a free tutorial on the inner workings of the major subsystems of the modern automobile. In collaboration with the Car Care Council, the site also provides a library of free information on preventive maintenance, fuel conservation, and the safe operation of motor vehicles. The site also lists links to other sites, as well as government recall notices.

AUTOSHOP–Online	Toll-Free: Website:	800-288-6220 www.autoshop-online.com

The AutoDigest Webline is a comprehensive site focused on providing information for both the automotive do-it-yourselfer and the automotive industry professional. The site includes the following features: AUTOLOOKUP, AUTORETAILERS, AUTODIRECTORY, AUTOMANUAL, AUTOVIEW, AUTOTIP, AUTOLINKS, AUTOSTORE, and PARTS LOOKUP. One feature, AUTOJOB, provides information about the times required for a variety of common vehicle maintenance and service repair jobs.

AutoDigest Webline	Website: E-mail:	www.autodigest.com autoboss@autodigest.com

The Automotive Service Association (ASA)—an international organization made up of approximately 13,000 member-businesses—has a Website that includes information on what's new in the industry, an online AUTOINC. Magazine, announcements of professional conferences and conventions, employment classifieds, auto tips, and related links.

Automotive Service Association P.O. Box 929 Bedford, TX 76095-0929	Phone: Toll-Free: Fax: Website: E-mail:	817-283-6205 800-272-7467 817-685-0225 www.asashop.org asainfo@asashop.org

The Automotive Parts & Accessories Association (APAA) has a Website for members and visitors. The site's car care information and consumer resources features include links to numerous sources of useful information: facts, tips, and hints; troubleshooting; tire care; regulatory information; car and company information; dealerships; books and videos; and help in locating parts. Included in the troubleshooting links are AUTOSHOP ONLINE; NUTZ & BOLTZ AUTOMOTIVE NEWSLETTER; AUTOSITE GARAGE; and AUTO-TALK (an automotive aftermarket news and technical training information service for professional technicians and auto service shop business owners and managers). Manufacturers' information on the site includes, for example, illustrated information from ACDelco on automotive battery technology, which could be printed and used as a classroom handout.

APAA 4600 East-West Highway Bethesda, MD 20814	Phone: 301-654-6664 Fax: 301-654-3299 Website: www.apaa.org E-mail: APAA@apaa.com

"Car Talk," heard on National Public Radio, has a Website whose features include FIND IT, WHAT'S NEW, DAILY TRIVIA, TALK TO CAR TALK, VIRTUALLY USEFUL DATA, SHAMELESS COMMERCE, and CAR TALK 101.

Car Talk	Website: www.cartalk.com

The Carpoint Website lets users research new and used cars by category (passenger cars, luxury cars, etc.) or by make and model; search a database of used cars for sale; or read articles with news and advice for car owners. Furthermore, the site includes an easy-to-use survey instrument you can use to get the *Kelley Blue Book* suggested trade-in value for any car.

Carpoint	Website: carpoint.msn.com

The Website of San Diego's Internet Community for Automotive Related Services includes a feature called GLOVE BOX TIPS FROM TED THE TECHNICIAN, with the ASE logo prominently displayed. Consumer information is provided on how to communicate for better automotive service, choosing the right repair shop, keeping your vehicle in tune with the environment, and getting your vehicle ready for summer. The site also provides extensive links to consumer/professional organizations, automobile manufacturers, products and services, consumer information, auto-related magazines, automotive mailing lists, and miscellaneous other auto-related links.

San Diego's Internet Community for Automotive Related Services	Website: webgarage.com

Ken Bachellerie, a professional transmission and differential technician, has created a Drive Train Page—an Internet magazine containing articles he has written on various transmission issues. The site also includes a page that does calculations. Type in tire diameter and engine RPMs at 60mph—it will calculate gear ratio. Type in gear ratio and engine RPMs at 60mph—it will calculate tire diameter. Type in gear ratio and tire diameter—it will calculate engine RPMs at 60mph.

Drive Train Page	Website: www.thegrid.net/thedrivetrainpage

The National Transportation Safety Board (NTSB) is one excellent source of traffic safety information.

NTSB 490 L'Enfant Plaza, SW Washington, DC 20594	Phone: 202-314-6000 Website: www.ntsb.gov

Another such source is the National Highway Traffic Safety Administration (NHTSA), Department of Transportation (DOT). Their Website includes vehicle and equipment information (including extensive information on air bags), traffic safety/occupant issues, a variety of databases (e.g., data on recalls), technical service bulletins, regulations and standards, and information about the DOT Auto Safety Hotline. Check the Website to locate the NHTSA office serving your region.

NHTSA/DOT	Auto Safety Hotline: 888-327-4236 Website: www.nhtsa.dot.gov

Safety-related information can also be found at the U.S. Environmental Protection Agency (EPA) Website, which includes information about the science of ozone depletion, regulations in the U.S. designed to protect the ozone layer, how car and truck A/C affects the ozone layer, new refrigerants, and fact sheets.

EPA	Ozone Protection Hotline: 800-296-1996 Website: www.epa.gov/ozone/index.html

Professional journals are a source of up-to-date instructional ideas for teachers in Automotive Technician programs. Consider subscribing to journals such as the following—or periodically reviewing their contents online:

Journal	**Website**
Journal of Industrial Teacher Education	scholar.lib.vt.edu/ejournals/JITE/jite.html
Journal of Technology Education	scholar.lib.vt.edu/ejournals/JTE/jte.html
Journal of Vocational and Technical Education	scholar.lib.vt.edu/ejournals/JVTE/jvte.html
The Journal of Technology Studies	scholar.lib.vt.edu/ejournals/JTS

Program Basics

Safety

Safety instruction should be provided, reinforced, and evaluated regularly throughout the two-year program. Instruction provided and evaluation results should be carefully documented and maintained for future reference.

All students should receive first-aid training, as well as instruction regarding how to respond to injury situations in accordance with the school's established procedures. CPR training (available through the local Red Cross or other recognized provider) is recommended.

Student medical forms ***must*** be obtained and taken to ***all*** off-campus activities. School policy regarding safety issues must be followed at all times.

Although ASE recommends that students road-test vehicles to diagnose mechanical problems and verify repairs, this may not be possible at the high school level due to liability concerns. ***Individual school policy must be followed.***

To comply with the Occupational Safety and Health Administration (OSHA) Right-to-Know Law, you should provide each student with information regarding the potential hazards of any chemicals with which he or she may come in contact in the learning laboratory and/or automotive technician shop. You must also follow local, state, and federal regulations in regard to buying, handling, and storing any hazardous products used in the laboratory or classroom. A material safety data sheet (MSDS) must be kept on file for each item requiring documentation.

Tools and Equipment

Lists of the hand tools, general lab/shop equipment, and specialty tools and equipment recommended for the support of instruction are provided in *ASE Program Certification Standards for Automobile Technician Training Programs*. It is recommended that each program comply with these lists insofar as possible—adding equipment as needed, depending upon local needs, equipment availability, and the number of students enrolled in the class.

Instruction related to equipment and tools must address the following programmatic issues:

1. ***Safety***—Equipment and tools must have all shields, guards, and other safety devices in place and be operable.
2. ***Type and quality***—The tools and equipment used in a certified program must be of the type and quality found in industry. They must also be adequate and in sufficient quantity to meet the program goals and student performance objectives.
3. ***Consumable supplies***—Supplies should be available in sufficient quantities to assure continuous instruction.
4. ***Maintenance***—A preventive maintenance schedule should be used to minimize equipment downtime.

5. ***Replacement***—A systematic schedule for replacement should be used to maintain up-to-date tools and equipment in accordance with industry and safety standards. Information gained from student program evaluations, as well as advisory committee input, should be used to guide the replacement process.
6. ***Inventory***—An inventory system should be used to account for tools, equipment, *parts, and supplies.*
7. ***Parts purchasing***—A systematic parts purchasing system should be used from work order to supplier.
8. ***Hand tools***—Each student should be encouraged to purchase a hand tool set during the period of instruction.
9. **Storage**—Adequate storage for tools—including space for storage of the students' hand tools—should be provided. A locked tool crib, individual student lockers, and locks on students' tool kits will help ensure security.

It is recommended that from the beginning of the program, students be made aware that for performance in the learning situation, ***quality*** is more important than ***quantity***. You need to emphasize continuously the importance of quality control and materials management. Students must learn to conserve—not waste—materials. This is a very important issue with employers as well as customers.

References

Having a wide variety of references available for everyone's use in the classroom and lab will help prepare students to locate the information they need using references on the job. References you might wish to consider—either as single copies or classroom sets—include the following. Many of these references are designed specifically for use in the preparation for ASE certification. Note that ASE requires that its certified programs use text/informational materials that carry a copyright date no more than 5 years old.

Delmar Publishers P.O. Box 15015 Albany, NY 12212	Phone: 800-865-5840 Website: www.thomson.com/delmar E-mail: info@delmar.com

Today's Technician Series

Each title includes a classroom/shop manual, instructor's guide, and classroom manager.

- *Automotive Brake Systems* by Lane Eichhorn & Drew Corninchock (1996)
- *Automotive Computer Systems* by Donald Knowles (1996)
- *Automotive Electricity & Electronics*, 2nd ed., by Barry Hollembeak & Jack Erjavec (1997)
- *Automotive Engine Repair and Rebuilding* by Barry Hollembeak (1997)
- *Automotive Heating and Air Conditioning* by Boyce H. Dwiggins (1996)
- *Automotive Suspension and Steering Systems* by Don Knowles (1995)
- *Basic Automotive Service and Systems* by Jay Webster (1995)
- *Manual Transmissions and Transaxles*, 2nd ed., by Jack Erjavec (1997)
- *Automatic Transmissions and Transaxles* by Jack Erjavec (1995)

Selected Other Texts

- *Automotive Technology: A Systems Approach*, 2nd ed., by Jack Erjavec & Robert Scharff (1996)
- *Motor Automotive Technology*, 3rd ed., by Anthony Schwaller (1999)
- *Automatic Transmission and Transaxles: Diagnosis and Service* by Mathias Brejcha & Ronald Tuuri (1997)
- *A Technician's Guide to ABS* by Jack Erjavec (1996)
- *Automotive Engines: Diagnosis, Repair, and Rebuilding*, 3rd ed., by Tim Gilles (1996)
- *Computerized Engine Control*, 5th ed., by Dick King (1997)
- *Automotive Air Conditioning*, 7th ed., by Boyce H. Dwiggins (1995)
- *Automotive Electricity and Electronics*, 3rd ed., by Al Santini (1997)

Goodheart-Wilcox South Holland, IL	Phone: 800-323-0440 Fax: 708-687-5068

- *Modern Automotive Technology* by James E. Duffy (1994)
- *Auto Fundamentals* by Martin W. Stockel, Martin T. Stockel & Chris Johanson (1996)
- *Automotive Encyclopedia* by William K. Toboldt & W. Scott Gauthier; Study Guide Editor: Nancy Henke-Konopasek (1995)

Instructional Materials Laboratory University of Missouri–Columbia	Phone: 800-669-2465 Website: www.iml.coe.missouri.edu E-mail: iml@tiger.coe.missouri.edu

Auto Technology Curriculum Guide

- Module 1: *Introduction to Automotive Technology* (1996)
- Module 2: *Electrical Systems* (1997)
- Module 3: *Engine Performance* (1994)
  - ~ Section A–Ignition System
  - ~ Section B–Fuel and Exhaust System
  - ~ Section C–Emission Control System
- Module 4: *Engine Repair* (1996)
- Module 5: *Steering and Suspension Systems* (1996)
- Module 6: *Brakes* (1996)
- Module 7: *Manual Drive Train and Axles* (1996)
- Module 8: *Automatic Transmissions and Transaxles* (1995)
- Module 9: *Heating/Air Conditioning* (1998)

Curriculum & Instructional Materials Center
Oklahoma Department of Vocational
& Technical Education
1500 West Seventh Avenue
Stillwater, OK 74074-4364

Phone: 800-654-4502
Fax: 405-743-5154
Website: www.okvotech.org/cimc

Automotive Technology Series

- *Parts Specialist*
- *Introduction to Automotive Services*
- *Brakes Specialist*
- *Steering and Suspension Specialist*
- *Heat and Air Conditioning Specialist*
- *Manual Drivetrains/Axles Specialist*
- *Electrical Systems Specialist*
- *Engine Performance Specialist*
- *Engine Repair Specialist*
- *Automatic Transmissions/Transaxles Specialist*

MOTOR Information Systems

Website: www.motor.com

- Repair Manuals
- Engine Performance & Driveability Manuals
- Air Bag Manual
- Emission Control Systems Application
- Transmissions Manuals
- Specification Guide
- Technical Service Bulletin Manuals
- Air Conditioning & Heater Manual
- Timing Belt Replacement Guide
- Wiring Diagram Manuals
- Component Locator Manuals
- Parts & Time Guides
- Labor Guide
- MOTOR Manual Updates
- MOTOR Magazine

Mitchell Repair Information Co.
9889 Willow Creek Road
San Diego, CA 92131

Phone: 619-549-7809
Toll-Free: 888-724-6742
Fax: 619-530-8986
Website: www.mitchellrepair.com

Electronic Products:

- ON-DEMAND Electronic Repair Information System
- ON-DEMAND for Transmissions
- Mechanical Parts and Labor Estimating System
- Mitchell RepairNet

Print Products:

- Master Manuals
- Training Manuals
- Parts & Labor Estimating Guides
- Transmission Manuals
- Special Diagnosis & Service

Automotive Lift Institute P.O. Box 3316 Indialantic, FL 32093	Phone: 407-722-9993 Fax: 407-722-9931

- Video: "Lifting it Right: A Safety Video for Automotive Lifts"

Organization of Instruction and the Learning Laboratory

Students need information, they need to observe demonstrations of the required skills, they need to practice, and their mastery of the skills needs to be evaluated. How and where these elements occur will depend on the structure of your particular program. In some cases, theory, parts, and system identification will occur in related instruction in a classroom setting, while demonstrations, practice, and evaluation occur in a shop setting.

In other cases, related instruction may occur right in the shop. If that is the case, try to create a setting there that is conducive to providing related instruction. For example, you could set aside an area in the shop with chairs/desktops, a chalkboard, a library reference area, provisions for using audiovisuals, and a podium for your use.

Whatever the setting, maintaining an organized learning area is a key factor to organized learning, as well as maintenance of a safe, secure laboratory. ***Good organizational skills begin with you, the instructor***. Students will be using a variety of tools and equipment to perform a multitude of manipulative skills ranging from detailed measuring to those requiring leverage and lifting strength. Human safety will always be a key issue in the auto tech shop, and maintaining a clean, organized work area is one factor in promoting safe practices.

How do the CDGs fit into this organization? The CDGs are not ***just*** lesson plans for the related classroom or ***just*** demonstration guides for the auto tech shop; they are both. Each is designed to outline the total instruction needed for students to achieve a particular competency. How you structure the related and shop portions of your particular lessons using the CDGs will be a local decision. You could start in the classroom (or the "classroom" area of the shop) with a presentation of the key points. Later, you could provide a demonstration in the shop to prepare students to begin to practice. Or, you could present the key points in the shop as part of a more extensive demonstration lesson. A CDG might be completed in one day, or it might be broken up and covered over a longer time period. You might be teaching alone, or sharing responsibility for the related and shop portions of instruction with another teacher.

Rotation Schedules

Since equipment and the number of practice components (chassis units, operable practice vehicles, or program vehicles) are usually limited, you may need to develop rotation schedules to ensure that all students have practice time on all competencies, with access to all the tools, equipment, and parts needed. Rotation schedules are also useful in assigning cleanup and maintenance task to ensure that everyone takes a turn at each task.

The simplest way to prepare a rotation schedule is to use an assignment or duty wheel. A duty wheel for cleanup and maintenance tasks could be prepared as follows:

- Cut a large circle out of stiff paper.
- Divide the circle into pie-shaped wedges, one for each student in the class. Print one student's name in each wedge at the outside edge of the circle.
- Cut a smaller circle out of stiff paper.
- Divide the smaller circle into the same number and size of pie-shaped wedges as in the large circle.
- Decide how to assign tasks to the wedges in the smaller circle, considering (1) the number of tasks to be performed and (2) the size of the tasks to be performed.

  For example, assume that the required tasks include equipment maintenance, office cleanup, locker room cleanup, water hose handler, parts & supplies inventory, safety manager, shop manager, tool room manager, sweeper, and floor washer. That's 12 tasks, and let's assume you have a class with 16 students—***more students*** than tasks.

  In a large facility, one solution would be to divide the facility into two areas and to assign two students as sweepers and two students as floor washers for each area. Thus eight of your wedges could be filled in as follows: sweeper–area 1; sweeper–area 1; sweeper–area 2; sweeper–area 2; floor washer–area 1; floor washer–area 1; floor washer–area 2; floor washer–area 2). Since these are menial tasks, it would be best if you spread them out around the circle, alternating them with the more interesting tasks so that an individual student doesn't sweep or wash floors two weeks in a row.

  If you have ***more tasks*** than students, then smaller, easier, quicker tasks can be grouped into one wedge and performed by one student.
- Write the tasks in the wedges as planned.
- Line up the centers of the two circles, with the smaller circle on top. Punch a hole through the centers, and join the two circles using a brass fastener (available at any office supply store).
- By rotating the inner circle, you quickly and easily rotate assignments.

A duty wheel for rotating students through practice activities would be developed in a similar manner. In this case, however, instead of printing the names of individual students on the wedges, you would divide your students into groups, and print the group designations in the wedges (Group 1, Group 2, etc.). The wedges on the other circle would list the work stations for practice (e.g., engine vacuum test, cylinder power balance test, cylinder compression test, cylinder leakage test).

The way in which you set up these stations to rotate through will depend on your program's organization, the class size, and available tools, equipment, and supplies. These factors will also determine how long students spend on each activity—how often activities rotate (e.g., weekly, biweekly). Whatever rotation schedule is selected, make sure that it is clearly communicated in advance to students.

In rotating practice, consider staggering the startup so that you, too, can rotate through the tasks, providing an initial demonstration for each group before they begin to practice. If an applied academics teacher is available, he or she can help supervise groups. Using more-advanced students to assist other students is also helpful—and auto techs need to be able to help and support each other on the job. Once initial demonstrations have been provided, you can circulate from student to student, observing, answering questions, reteaching, and reinforcing key concepts as needed.

Individual Career Plans (ICPs) and Career Passports

Every student in Ohio should have an individual career plan (ICP). The ICP is a learning process for students that begins in the elementary years (K–5) with career information and exploration activities designed to prepare students to make educational and tentative career decisions in the middle grades.

In the middle-grade years (Grades 6–8), specific and organized activities provide the basis for students to identify and explore initial career goals and identify the educational plan needed to achieve those goals, both at the secondary level and beyond. This is the ICP document.

At the high school level, students continue to explore and verify their educational and career goals and to formally review, revise, and add to their ICP document annually.

The ICP document can include forms for students to record relevant personal information, their education history, the results of tests and assessments taken, work-based experiences, courses taken or completed, extracurricular activities, educational plans, career goals, and activities leading to those goals. A crucial component of the ICP is documentation of the employability and technical skills mastered. For students in Automotive Technician programs, these would be the competencies contained in Ohio's Occupational Competency Analysis Profile (OCAP) for *Automotive Technician*, which include both employability skills and the technical skills from the *ASE Program Certification Standards for Automobile Technician Training Programs*.

Once completed, these records can be compiled into a portfolio the student can use in presenting his or her achievements and qualifications to potential employers. In Ohio, this portfolio is called the Career Passport. Just as a U.S. passport provides the documentation needed by a traveler to enter a foreign country, a Career Passport provides the documentation a student needs to enter the world of work.

Professional-quality ICP folders and inserts and Career Passport portfolios are available through the Publications Office at the Center on Education and Training for Employment. (For additional information, call 800-848-4815, ext. 2-4277; or 614-292-4277).

Individual Educational Plans (IEPs)

Many classes include students with IEPs written specifically to address individual students' special or exceptional needs. Each plan should be developed with the direct involvement of the school counselor, program instructor, and parents or guardians, who have a legal and moral responsibility to plan and monitor the educational experiences of all children so they can be prepared to be gainfully employed.

All parties must be fully aware of the student's capabilities as well as the expectations of potential local employers. It is unfair to prepare a student for employment only to find that some impairment will restrict the student from being gainfully employed upon graduation. Identify those areas of employment (perhaps in the peripheral related areas) that can be accessible to graduates who have specialized or limited skills.

All parties involved in the IEP development process should communicate regularly so that each party has a clear understanding of the IEP and how it is to be implemented. Students with IEPs should be evaluated in accordance with school policy, which will usually require varied criteria.

Assessment

Ongoing evaluation of student achievement is necessary for program accountability and to monitor student progress. A variety of informal and formal evaluation methods should be used. Informally, you can monitor student performance during instruction. Are they actively listening? Are their questions on target? Do their comments indicate understanding? In the shop, you can observe students as they practice skills and ask questions to verify their understanding. Formally, you can administer quizzes and knowledge tests and evaluate final performance and products.

Each CDG ends with a checklist for evaluating performance. The checklist criteria represent the key standards for performance on the job. If local conditions require, you may add criteria to a checklist so that it reflects more exactly what you will be looking for in a student's performance. Input from advisory committee members, along with that of other local employers, can be of great assistance to you in establishing the student performance standards expected and the evaluation criteria.

Students should be given copies of the checklist before they begin to practice so they know what criteria they are expected to meet. Ask them to use the checklists to self-evaluate. When a student thinks he or she can meet the criteria, that's the time for teacher evaluation.

In rating performance, 5 is the highest level; 1 is the lowest. To get a sense of what these levels mean, consider the following anchor ratings:

Level 1	Level 3	Level 5
Unable to complete task in timely manner	Work slightly exceeded time standards set by instructor	Work performed within time standards set by instructor
Total disregard of prescribed safety standards	Failure to comply with one or more safety standards	Full compliance with safety standards as prescribed by manufacturer/industry
Total failure to follow proper procedure(s)	Some steps in procedure missed or performed inexactly	Manufacturer's procedures followed precisely
Total failure to meet manufacturer's specifications	Work performed slightly outside manufacturer's specifications	Work performed accurately within manufacturer's specifications
Total failure to maintain clean work area/vehicle	Some standards of cleanliness missed or performed inexactly	Clean work area/vehicle maintained
Unacceptable quality of work performance	Average quality of work performance	High quality of work performance
Required considerable supervision	Required moderate supervision	Performed with minimum supervision

Your advisory committee can help you establish the anchor ratings you will use. At a meeting early in the year, members could be asked to review the anchor ratings and come to consensus on the standards, as well as the factors that should be considered in assigning a *2* or *4* rating. If they have signed off on the standards to be met, they should be more inclined to hire graduates of the program.

Following teacher evaluation, the student and teacher should meet and compare ratings. If the student's ratings vary from those of the teacher, the reasons for these variations should be addressed. Workers need to be able to accurately self-evaluate their performance on the job. A worker whose "completed" work is routinely below standard is unlikely to last long.

Students whose performance does not meet the criteria should not get a grade and move on to the next skill. You and the student should devise additional practice activities so that the student can improve where needed. His/her performance should then be reevaluated. Bear in mind that this need not involve a great deal of extra time. In many cases, the student will only need to work on part of the performance—and the second evaluation can focus only on that part. Bear in mind, too, that students should not be recycled through additional practice and reevaluation to infinity. If a student is not making reasonable progress, other steps may need to be taken.

Completed checklists can be retained to document student progress and achievement. For example, you could prepare a file folder for each student and place each completed checklist in the file—preferably in a file drawer that locks.

When a student successfully performs a skill, that skill could also be checked off on a student progress chart. Using individual student progress charts to monitor student competency achievement can be very helpful to both you and the student. The student can check the posted progress chart daily to determine which skills he or she needs to practice. Student progress charts can also be maintained on a computer that is accessible for student use.

Evaluation and grading policies will vary from school to school. Some school districts may require two grades for the vocational program (e.g., one for the related theory class and one for performance in the learning laboratory or on the job). Other schools give only one grade for the vocational program. Some schools may include individual participation in the vocational student organization, daily attendance, attitude, etc., in the final grade. You need to follow your school's established grading policies.

Additional Program Elements

Customer Service Orientation

For many people, their vehicle is a key factor in their success—it provides a means of transportation for a variety of purposes on a daily basis. It is a possession that can provide a lot of pleasure as well as a level of independence for daily living activities. When that vehicle is unreliable, much frustration can result. Thus, the automotive technician has a very important role in society. A big part of the technician's job involves dealing with the customer—either directly, or indirectly through a service manager or supervisor. Technicians need to be good listeners.

It is critical for students to realize the importance of listening to customers. Once students reach a competence level where they are working on customer-owned vehicles, it is important for students to learn to interview a customer to verify a customer's complaint. Technicians need to practice developing communications skills and learn how to interact with customers on a one-to-one basis. The information gleaned during a customer interview can often provide specific detail to assist with solving a problem, troubleshooting repairs, or diagnosing a malfunction.

Professionalism and Maintenance of ASE Certification

We need to instill in students the importance of remaining current with the profession after they graduate. With the continually changing technology, continuing education is a must. ASE is recognized nationally for its outstanding professional program, making its technician certification attractive and transferable from state to state. Having vocational instructors and programs that are ASE-certified demonstrates to the community that the best educational opportunities are available to the students in the program. The ASE symbol is recognized by many people in the community. Those who have invested time and money in this certification display its symbol with pride.

Vocational Student Organization (VSO) Participation

Student participation in the vocational student organization—Vocational Industrial Clubs of America (VICA)—and in its sponsored competition and leadership activities should be encouraged. Leadership training gained within the VSO can provide valuable insight for those students who may aspire to management and/or entrepreneurial positions.

National VICA has available two major curricular products designed to support instruction and facilitate partnerships between business, industry, and education:

- *Professional Development Program* (PDP)—a school-to-work employability skills training curriculum that guides students through activities related to communications, ethics, conflict resolution, government awareness, time-management skills, career research, etc. The program enables instructors to become managers of the learning process, encourages students to become responsible for their own learning and development, and fosters the involvement of local businesses in the training of tomorrow's entry-level workers.
- *Total Quality Curriculum* (TQC)—provides a vehicle for incorporating Total Quality Management (TQM) principles into daily classroom activities. The curriculum includes an overview of the quality movement and covers such concepts as productivity growth, customers and customer satisfaction, continuous improvement, quality teams, idea generation, reaching consensus, decision making, and use of charts and diagrams.

VICA also holds one-day PDP and two-day TQC training seminars.

National VICA
P.O. Box 3000
Leesburg, VA 20177-0300

Phone: 703-777-8810
Toll-Free: 800-829-8727
Fax: 916-684-5225
Website: www.vica.org

Academic/Vocational Integration

Whenever possible, you should reinforce academics in your instruction and be willing to work with the academic teachers who teach your students—coordinating instruction between the vocational and academic classes and, if possible, helping the academic teachers add an occupational context to their instruction. Each CDG provides a few suggestions for ways of involving these teachers, but you can do more. For example:

- Invite academic teachers into your classroom or shop to observe. Visit their classrooms as well.
- Invite academic teachers to be part of advisory committee meetings.
- Share materials (e.g., texts, journals, specification manuals, MSDSs, automotive dictionaries, and authentic materials used by auto techs on the job), as well as leads to other sources (e.g., Website addresses).
- Develop joint lesson or project plans.

You and the academic teachers can find lists of the mathematics, science, and communications competencies that are critical to auto technicians by referring to two resources:

- *Applied Academic and Workplace Skills for Automobile Technicians* (1995), available from NATEF (Phone: 703-713-0100; Website: www.natef.org)
- Occupational Competency Analysis Profile (OCAP) for *Automotive Technician* (1996), available from the Publications Office of the Center on Education and Training for Employment (Phone: 800-848-4815, ext. 2-4277; or 614-292-4277)

An additional resource that can be of great help is *Making Connections: A Curriculum Ideabook for Teachers of Applied Academics and Industrial & Engineering Systems.* This 1998 document is full of activities and strategies to help trade & industrial teachers and academic teachers integrate their curricula. It also provides lists of Internet sites and curricular resources (e.g., textbooks, workbooks) that support an integrated approach. *Making Connections* is also available from the Publications Office of the Center on Education and Training for Employment.

Please note that, although the activities suggested in the CDGs for academic coordination address primarily mathematics and science, this is not to suggest that communication skills are not critical. Rather, these skills tend to cut across all competencies:

- Auto technicians need strong speaking and listening skills in order to deal with customers, whether in person or on the phone. They must have good questioning skills to obtain the information they need. These skills are also needed in working with supervisors and coworkers.
- They need to be able to write up service orders and work orders and parts orders in a clear, legible, accurate way, with terminology spelled correctly.
- They are in critical need of strong abilities to use written resources (TSBs, parts manuals, service manuals, specification manuals). They must be able to locate information and interpret it, whether in text, graphic, chart, or tabular form.

Guest Speakers

Even the most conscientious teacher can't always keep up with the sometimes rapid changes in the field: new equipment, new procedures. Even the most experienced teacher is unlikely to have equal expertise in every area of the occupation. Inviting experts into the classroom as guest speakers can fill this gap—and provide instructional variety as well.

For example, representatives of tool and equipment manufacturers can be invited to discuss special products and equipment used by auto technicians. Specialized competencies can be discussed and demonstrated by advisory committee members, employers, representatives from manufacturers and professional organizations, and/or former graduates.

Visits by guest speakers should be ***planned*** events. Before the event, students should be given some background information about the expert and the topic of his/her presentation. They should be told what will be expected of them during and after the visit (e.g., taking notes, preparing a report). Having them develop a list of questions they want the expert to answer is also a good preparation activity. Student volunteers can take responsibility for certain activities related to the visit (e.g., meeting the guest and escorting him/her to the class location on the day of the visit; writing and sending a thank-you letter after the visit).

Field Trips

Class field trips to observe real-life work processes performed by certified auto technicians provide realistic learning experiences for the students. This is excellent opportunity to utilize the expertise of the advisory committee members. They may be able provide field trips to their own firms, suggest other relevant field trip sites, and/or assist in chaperoning students during a field trip.

Trips can be arranged to a manufacturer, dealership, parts center, specialty service center, auto center affiliated with a franchise operation or local retailer, or small independent automotive technician shop. Trips may involve simple walk-throughs and brief presentations by various workers at the site. Or demonstrations may be presented (e.g., of new or very expensive specialty equipment not available in the school shop). Such experiences give students the opportunity to see and hear firsthand about the occupation. It is a true reality check.

Job Shadowing or Mentoring

Job shadowing means following a worker around on the job and observing the tasks performed—usually for a short time period. *Mentoring* involves pairing an experienced worker—a mentor—with a student; the mentor provides the student with information and advice. Either of these activities can enhance the learning process and provide rich opportunities for career exploration and job awareness.

It is recommended that all students—both junior and senior—be aligned with an experienced worker in the automotive technician industry (perhaps a member of the advisory committee) so they can get a realistic view of what happens on the job. Providing students with the opportunity to interact with strong, successful role models can be a very important component of the training program.

These experiences need to follow a structured plan, and all school policies must be adhered to. The assignments may be teacher-arranged, or students may be responsible for making all arrangements themselves, including identifying the individual they will shadow or the mentor they will be paired with. Regardless of how the experiences are arranged, each student should be responsible for sending a letter of introduction prior to the assignment and a thank-you letter following the assignment.

Job Experiences

Job experiences come in a variety of forms. They can be called *early job placements* or *internships* or *cooperative experiences*. They may be paid or unpaid. They may be full- or part-time. They may take place before or after school. They may occur in place of school for a certain time period (e.g., second half of the senior year). Or the student might spend a half day at school and a half day on the job. What the experiences have in common is exposing the student to the reality of the workplace, with a real role in participating.

These experiences are generally quite positive and very important. The technology in the automotive technician profession is changing rapidly, and employers are often happy to hire young, enthusiastic graduates who are eager to learn and who can benefit from early on-the-job training and experience.

The investment in training and the cost of specialized equipment required for an auto service shop is sizable. The school, students, and parents must recognize that the employer's acceptance of a student into a job experience is a compliment to the school program—an honor a student must earn. Policies governing these placements must be established, and all parties must be aware of potential liability involved if the guidelines are not adhered to.

Such guidelines might include requiring that the student do the following:

- Complete all the preliminary paperwork prior to placement assignment (e.g., school forms, letters of introduction, appropriate thank-you letters).
- Earn and maintain specific grades.
- Demonstrate a positive attitude toward school and the automotive technician profession.
- Demonstrate good school attendance (limited number of tardies and absences).
- Maintain above-average performance at the job placement assignment.
- Comply with all school and employer policies.
- Provide his/her own transportation to and from school and work.

In addition, ***students must have an untarnished driving record to ensure their employment.*** Once a graduate is employed, it will be necessary for the technician to be bondable so she or he can work on customer-owned vehicles and possibly test-drive the vehicle (depending on employer policies). Drug screening is also a commonplace requirement of employment these days. Students need to be made aware of these employment conditions—and to take them seriously.

Implementing job experiences is another time when the advisory committee members can be very helpful to the Automotive Technician program. Advisory committee members can let students know how important attendance, attitude, and mastery of program competencies are in order to qualify for these placement opportunities. Advisory members can also often provide placement positions for qualified students.

Activity Options

Each CDG provides activities requiring students to apply the skills they are learning, but you are welcome to substitute or add other activities of your own. The following are examples of the types of activities you might want to consider. Bear in mind that almost all of these activities could be carried out by students working either individually, in small teams, or as a whole class. Providing for both individual work and teamwork can make instruction more interesting—and more consistent with how work is performed in the real world.

Have students identify tools, equipment, supplies, and components; for example:

- Give students sheets with different vehicle labels, and have them interpret the codes.
- Give students teacher-developed worksheets requiring them to match symbols and letter designations with the components and wiring connections they represent.
- Give students a teacher-prepared diagram of an air bag system, and have them label the components.
- Give students a diagram of a cooling system, and have them indicate the potential trouble spots.
- Give students a specific model of automatic transmission, and have them diagram the circuits that can be checked.
- Have students diagram the manual shift valve and throttle (TV) linkages or cables and label the parts.
- Have students diagram how coolant flows through a transmission cooler with a transmission oil cooler and line flushing tool attached.
- Provide students with a disassembled transmission, and have them identify all parts and the gears in which the parts are applied.
- Prior to assembly, have students lay out the parts in the order in which they will go into the transmission.
- Have student identify types of taps and dies (e.g., size them to a thread).
- Assign students specific vehicles, and have them identify the correct type and weight of oil for each vehicle.
- Have students set up the special tools required for strut disassembly.
- Write wrench sizes on board. See which student can get a box of wrenches to match the board order first.

Have students develop written materials to guide their performance of job tasks; for example:

- Have students develop an interview form with sample questions to ask customers and devices (e.g., checklists) to use in recording the customer's responses quickly and accurately.
- Have students develop a procedure sheet for adjusting mechanical valves on a given vehicle (as specified by instructor) that can be used to guide student practice in the lab.
- Have students design a diagram of the lug nut tightening sequence.
- Have students develop a table describing PCV valve operation under various driving conditions.

- Have students design a chart they can use to record their readings when testing an engine with a vacuum gauge.
- Have students develop a chart listing where leaks are heard on a vehicle (Column 1) and the possible causes for each (Column 2).
- Set up a display of worn components (worn clutch disc, warped flywheel, broken pressure plate fingers, noisy release bearing), and have students prepare a table, naming each condition and listing the problems each might present.
- Divide students into small groups, and assign each a particular vehicle. Have each group develop a procedure sheet on how to select and install brake fluid for the assigned vehicle, including all safety precautions. Then ask students to compare sheets and note commonalities and differences between procedures.
- Have each student develop a chart or checklist of items to look for when diagnosing wheel bearing troubles. Ask them to be specific and to place items in order of importance, with the most likely troubles first, and so on.

Involve students in role-playing and team-building activities; for example:

- Have students divide into pairs and role-play the customer interview process. For example, school personnel or students in other classes could be interviewed about vehicle problems they are experiencing or have experienced in the past.
- Divide students into small groups, and give each student in the group only one piece of diagnostic information. This will force students in the group to talk with each other and cooperate in order to identify the needed repair.
- Have students role-play instructing a customer in how to check and maintain proper inflation pressure to get the best ride and wear from the tires.
- Provide pairs of students with repair problems, and have one student role-play the service advisor and one student role-play the customer. The service advisor's task is to prepare a service order with customer input and communicate solutions to the customer.
- Provide pairs of students with a parts catalog, and have them role-play phone contacts, with one student playing the role of parts person and one student playing the role of technician seeking parts information.

Provide students with worksheets and case studies that require them to solve problems; for example:

- Provide students with a flat rate manual, typical labor jobs, and a labor rate per hour, and have them calculate labor costs.
- Give students electrical diagrams with practice problems, and have them solve them using Ohm's law.
- Give students a list of vacuum gauge readings, and have them identify possible causes for each reading.
- Give students sheets with questions to answer by locating and interpreting the labels on specific vehicles.
- Give students a variety of diagnostic information, and ensure that some of the information is ***not*** applicable to the problem. Have them determine needed repairs using a service manual.
- Use a wiring diagram to indicate a vehicle fault (perhaps an open on a parking lamp), and have students indicate what test light and/or DMM readings they think this fault would produce. Then have students introduce the fault into the vehicle and determine the actual reading it produces.

- Give students a written case study describing a specific overheating problem, and have them troubleshoot that problem.
- Give students written case studies describing different types of fire situations, and have them select the correct type of extinguisher and correct overall response for each situation.

Involve students in research; for example:

- Have students determine what factors are involved in how the manufacturer decides what the tire pressure should be.
- Have students locate five sites on the Internet that contain service information.
- Give students access to technical service manuals, and have them locate the information necessary to replace a particular part (e.g., head gasket) on a given vehicle.
- Give students a fluid replacement booklet, and have them determine what type of fluid a certain transmission, radiator, and engine should use.
- Have students locate the material safety data sheets (MSDSs) and local guidelines for the flushing solutions used in the shop and outline the proper procedure for disposing of each solution.
- Have students research the effects of contaminated refrigerant on the refrigerant handling equipment used in the shop and report on their findings.

Provide opportunities for students to use other talents (e.g., communication skills, artistic skills); for example:

- Ask students to design handouts, posters, etc., to alert customers to the effects on tires and ride if the wheel and tire assembly is not balanced correctly.
- Have students work in teams to develop safety posters, fliers, handbooks, etc., covering the use of personal safety equipment in the shop.
- Have students work in teams to create their own label for R-12 as if they were the manufacturer. How would they design a label that clearly and easily communicates the cautions and warnings to the user.

Provide guided practice of the whole task and/or the various smaller skills required in task performance; for example:

- With permission from local parts suppliers, allow students to call for "estimates" on vehicles they diagnose in the laboratory. Ask them to record all prices, quantities, part numbers, etc., on given repair estimate form.
- Have students measure various clutch discs using a micrometer.
- Have students divide into teams and practice using the oscilloscope by creating faults and interpreting the readings.
- Provide students with a soft metal (1/2"-thick aluminum is good). Have them select a bolt size, correct drill bit and tap to use, and then drill and tap a hole to correct size for that bolt. Finally, have them install bolt and tighten it to test the new thread's strength.
- Provide students with examples of faulty wheel bearing components, and have them identify the possible causes of the failure.
- Ask students to match tire rotation (cross) patterns to the correct vehicle (e.g., front-wheel drive, rear-wheel drive).
- Have students practice performing steering operating inspections and determining needed repairs.
- Hold a clinic for other classes to give students a chance to practice techniques for bleeding brakes.

- Create leaks in a coolant system (e.g., by loosening the clamps), and have students use the appropriate checks and tests to locate the problem.
- Provide students with various oils, and have them determine the weight and applications of each.
- Have students practice performing oil lubrication system priming on three different vehicle engine assemblies.
- As students practice performing a cylinder power balance test, quiz them individually on the process (e.g., ask them to itemize the precautions to be taken during the testing process, including the related safety concerns).
- Disable one or more vehicles, and have pairs of students work together to diagnose the cause of the no-starting problem.
- Have students practice replacing fuel filters on one vehicle with a gasoline engine and one vehicle with a diesel engine and then compare the two replacement procedures.
- Set up stations, with each station having one used tire exhibiting wear caused by a different specific cause. Divide students into teams and have them rotate through the stations, inspecting each tire and identifying its degree of wear and wear pattern. Then have the teams compare their observations and results.
- Set up vehicle with headlights on and engine at 2,000 RPM, and have students use DMM to check for AC voltage at battery (max .4 volts AC).
- Have students remove and reinstall connectors and then verify the operation of all circuits going through the connectors.
- Have students use a digital multimeter to check voltage drop across (a) a tight terminal, (b) a loose terminal, (c) a corroded terminal, and (d) a clean terminal.
- Have students check current draw on an engine cooling fan.
- Provide students with a heater, a solution of antifreeze and water, a thermometer or pyrometer, and a thermostat, and have them heat the solution and note the temperature at two points: (a) when the thermostat begins to open, and (b) when the thermostat is fully open.
- Ask students to determine the freeze point of coolant in a given car using a coolant freeze point tester and then indicate whether that freeze point is adequate for the locality in which the school is located.
- Ask students to perform an instructor- or school-prepared safety inspection of the entire automotive laboratory.

Insert the
"Engine Repair"
Tab Here

Units 1/8: Engine Repair/Engine Performance

Subunits 1.1/8.1: General Engine Diagnosis; Removal and Reinstallation (R & R)

Competencies 1.1.1/8.1.1: Interpret and verify complaint; determine needed repairs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Interpret and verify a customer concern, and determine needed repairs
Criteria:	In accordance with the criteria in the checklist for Competencies 1.1.1/8.1.1

Introduction:

General Introductory Techniques: Share personal experiences you have had when interpreting and verifying customer concerns in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Explain that auto technicians need to listen to customer concerns; customers know how their vehicles typically perform—and they can often provide useful information when those vehicles are not performing as usual. Discussing the information they provide—along with what you, as auto technicians, know about vehicle operation—can assist you in diagnosing and troubleshooting problems and determining needed repairs.

2. Ask students: What types of questions would you ask to help the customer explain his or her vehicle's problem(s)?

3. Ask students: What could you do to let the customer know you are paying attention to his or her explanation and genuinely concerned about the problem?

References:

Technical service bulletins (TSBs); "Noise Description" handouts available from local car dealerships. (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Importance of Accurate Diagnosis	2. ***Remember:*** The key to building reputation is, "If it's not broken, don't fix it." Stay focused on customer's concerns and vehicle problem.
3. Interviewing the Customer	3. Pay attention and listen carefully to the customer. Provide feedback (e.g., nod or say "okay" or "tell me more") to indicate that you are hearing what the customer is saying. Show genuine empathy for the customer's concern. Never "talk down" to a customer. You are the technician—the expert—but be courteous. Ask probing questions (e.g., "At what speed or temperature does that occur?" or "Please describe for me exactly what it sounds like").
4. Recording Information	4. Take notes during the interview to record the key points emphasized.
5. Looking Up Information	5. Refer to TSBs and service manuals. These resources contain technical information and cues that will help you diagnose and verify the complaint/ problem.

Presentation Outline	Steps to Cover/Key Points to Make
6. Finding the Problem	6. Look, listen, feel, probe, and disassemble as needed to gain access to vehicle components. Perform actions necessary to demonstrate/duplicate problem described.
7. Determining Needed Repairs	7. Using diagnostic information gathered, refer to service manuals to identify needed repairs.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied communications teacher may help students with interviewing techniques, design of probing questions, and recording of pertinent information.

Review:

Ask students review questions such as the following:

1. How important is it for the auto technician to make an accurate diagnosis of the vehicle's problem?
2. Why is it important to show empathy toward the customer and concern for the customer's vehicle?
3. What types of questions would be appropriate to ask the customer to help identify the problem?

Application:

1. Have students develop an interview form with sample questions to ask customers and devices (e.g., checklists) to use in recording the customer's responses quickly and accurately.
2. Have students divide into pairs and role-play the interview process. For example, school personnel or students in other classes could be interviewed about vehicle problems they are experiencing or have experienced in the past.
3. Give students written case studies describing customers' explanations of their vehicle problems. Have the students list step by step exactly how they would proceed in order to interpret and verify each customer's concern(s).

Evaluation:

- √ Each student will interpret and verify a customer concern and determine needed repairs. His/her performance will be evaluated using a copy of the performance checklist for Competencies 1.1.1/8.1.1.

Competencies 1.1.1/8.1.1: Interpret and verify complaint; determine needed repairs

Performance Checklist

In interpreting and verifying a customer concern and determining needed repairs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Interviewed customer to verify problem	☐	☐	☐	☐	☐
4. Paid attention and listened to customer	☐	☐	☐	☐	☐
5. Was courteous and empathetic	☐	☐	☐	☐	☐
6. Asked probing questions that would help identify problem	☐	☐	☐	☐	☐
7. Referred to appropriate technical service bulletins and/or service manuals	☐	☐	☐	☐	☐
8. Accurately recorded key points made during interview	☐	☐	☐	☐	☐
9. Performed actions necessary to demonstrate/duplicate problem described	☐	☐	☐	☐	☐
10. Determined needed repairs	☐	☐	☐	☐	☐
11. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____ **Date**______________

Unit 1: Engine Repair

Subunit 1.1: General Engine Diagnosis; Removal and Reinstallation (R & R)

Competency 1.1.5: Perform engine vacuum tests; determine needed repairs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Perform an engine vacuum test, and determine needed repairs
Criteria:	In accordance with the criteria in the checklist for Competency 1.1.5

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when performing engine vacuum tests and determining needed repairs. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Prior to the availability of today's electronic diagnostic equipment, auto technicians used a simple vacuum gauge to assist them in locating engine trouble.

2. Display a vacuum gauge; pass it around the class.

3. This gauge is still in use today. A simple vacuum test can identify internal engine conditions and lead you directly to a problem. The vacuum gauge is still one of the most important engine diagnostic tools the auto technician has.

References:

Technical service bulletins (TSBs); charts showing various vacuum readings. (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Stay clear of moving parts (e.g., fan belts).
3. Vacuum Gauge	3. Gauge measures in Hg (inches of mercury). It usually reads "0–30"; has a 1'–3' rubber hose attached. Vacuum is a pressure less than atmospheric (14.7 psi).
4. Performing Vacuum Test	4. Engine should be at normal engine operating temperature. Follow manufacturer's specifications. Steps in vacuum test procedure for a specific vehicle Inspect (examine, feel, bend, squeeze) all vacuum hoses, checking for holes, cracks, kinks, etc., that can alter the readings.
5. Analyzing Test Results	5. Consult service information for specific specifications/results. Present results to customer in the form of "general rules of thumb." ***Tip to remember:*** The gauge reading will drop about 1"Hg for each 1,000 feet since you are above sea level.

Presentation Outline	Steps to Cover/Key Points to Make
6. Determining Needed Repairs	6. Using diagnostic information gathered, refer to service manuals to identify needed repairs.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher may assist students with understanding atmospheric pressure.

Review:

Ask students review questions such as the following:

1. What is a *vacuum*?
2. How (by what increment/standard) is vacuum measured?
3. If there are low vacuum readings on an engine, what could be the cause?

Application:

1. Have students develop procedure sheets for performing an engine vacuum test for particular vehicles.
2. Have students design a chart they can use to record their readings when testing an engine with a vacuum gauge.
3. Give students a list of vacuum gauge readings, and have them identify possible causes for each reading.

Evaluation:

√ Each student will perform an engine vacuum test and determine needed repairs. His/her performance will be evaluated using a copy of the performance checklist for Competency 1.1.5.

Competency 1.1.5: Perform engine vacuum tests; determine needed repairs

Performance Checklist

In performing an engine vacuum test and determining needed repairs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Ensured that engine was at normal operating temperature	☐	☐	☐	☐	☐
5. Performed engine vacuum test in accordance with service procedures	☐	☐	☐	☐	☐
6. Inspected all hoses for conditions that could alter readings	☐	☐	☐	☐	☐
7. Compared test results to specifications/results provided in service information	☐	☐	☐	☐	☐
8. Determined needed repairs	☐	☐	☐	☐	☐
9. Presented results in the form of "general rules of thumb"	☐	☐	☐	☐	☐
10. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competencies 1.1.6/8.1.6: Perform cylinder power balance tests; determine needed repairs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Perform a cylinder power balance test, and determine needed repairs
Criteria:	In accordance with the criteria in the checklist for Competencies 1.1.6/8.1.6

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when performing cylinder power balance tests and determining needed repairs. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. There must be a ***balance of power*** within the engine in accordance with the manufacturer's specifications.

2. A cylinder power balance test allows you to quickly determine whether all of the engine's cylinders are producing the same amount of power.

References:

Technical service bulletins (TSBs), Analyzer's Hook-up Instructions. (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling***. However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, *for more information.*

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Be constantly aware of moving parts in the engine compartment as you perform the cylinder power balance test. Exhaust removal system ***must*** be used when engine is running inside the auto shop. Exhaust can be deadly!
3. Rationale for Testing Power Balance	3. Ideally all cylinders should produce the same amount of power, This minimizes the power losses that occur when some cylinders have to keep a "weak" one going or "in balance" with the others. A power balance test can signify problems with valves, leaky intake or cylinder head gaskets, piston rings, and fuel or ignition systems. It can locate misfires, a dead miss, or a weak cylinder.
4. Test Tools	4. Engine analyzer Tachometer Ground wires

Presentation Outline	Steps to Cover/Key Points to Make
5. Performing Power Balance Test	5. Engine should be at operating temperature when being checked. More than one way to test: • Connect tachometer and remove the plug wires one by one to check performance. • Connect engine analyzer, then "short-out" one cylinder at a time to determine each cylinder's performance. • Measure "power change" by the RPM drop on the tachometer when the cylinder is shorted-out. Test RPM drop of each individual cylinder (as compared to other cylinders) using hookup procedure specified by manufacturer.
6. Standard Precautions When Performing Tests	6. Electronic ignition vehicles: • When removing plug wire, do not leave an excessive gap between plug wire and ground. Doing so could damage the system. • Attach a spark tester to plug wire, then ground it prior to running vehicle on each cylinder. If vehicle is EGR-equipped, consult service manual for precautions. Manual must be followed to prevent damage. ***Know the vehicle!*** If vehicle is equipped with a catalytic converter, do not run for more than 15–60 seconds with plug shorted-out. This will help prevent too much unburned fuel from entering the system and possibly causing damage. Also, allow the engine to run 30–60 seconds after reconnecting the plug so that the engine and converter can stabilize prior to your testing of the next cylinder. If vehicle has an Oxygen Sensor, feedback-type carburetor, and/or AIR system, refer to manufacturer's information prior to testing.

Presentation Outline	Steps to Cover/Key Points to Make
7. Analyzing Test Results	7. Each cylinder's RPM drop should be within 10% of that of other cylinders. When reviewing the RPM drop, note the cylinder(s) having the lowest RPMs or the highest amount of RPM drop. These are the weaker cylinder(s).
8. Determining Needed Repairs	8. Using diagnostic information gathered, refer to service manuals to identify needed repairs.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher may assist students in understanding RPMs.

Review:

Ask students review questions such as the following:

1. Why should all engine cylinders produce basically the same amount of power?
2. If the power being produced by each engine cylinder is not the same, what are some likely causes of this imbalance?
3. If a customer came into the shop and told you that his or her vehicle was idling rough, how would performing a power balance test assist you in identifying the idling problem?

Application:

1. As students practice performing a cylinder power balance test, quiz them individually on the process (e.g., ask them to itemize the precautions to be taken during the testing process, including the related safety concerns).
2. Give students a sample power balance sheet, and have them identify possible causes of problem.

Evaluation:

√ Each student will perform a cylinder power balance test and determine needed repairs. His/her performance will be evaluated using a copy of the performance checklist for Competencies 1.1.6/8.1.6.

Competencies 1.1.6/8.1.6: Perform cylinder power balance tests; determine needed repairs

Performance Checklist

In performing a cylinder power balance test and determining needed repairs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Ensured that engine was at normal operating temperature	☐	☐	☐	☐	☐
5. Performed cylinder power balance test in accordance with service procedures	☐	☐	☐	☐	☐
6. Took standard precautions during testing related to specific vehicle being tested (e.g., electronic ignition, EGR-equipped, catalytic converter, Oxygen Sensor feedback-type carburetor or AIR system)	☐	☐	☐	☐	☐
7. Analyzed test results	☐	☐	☐	☐	☐
8. Identified the cylinder(s) with the lowest RPMs or highest amount of RPM drop	☐	☐	☐	☐	☐
9. Determined needed repairs	☐	☐	☐	☐	☐
10. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____ **Date**______________

Units 1/8: Engine Repair/Engine Performance

Subunits 1.1/8.1: General Engine Diagnosis; Removal and Reinstallation (R & R)

Competencies 1.1.7/8.1.7: Perform cylinder compression tests; determine needed repairs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Perform a cylinder compression test, and determine needed repairs
Criteria:	In accordance with the criteria in the checklist for Competencies 1.1.7/8.1.7

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when performing cylinder compression tests and determining needed repairs. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. When trying to identify engine performance problems, it is often wise and necessary to perform cylinder compression tests. This type of test helps determine whether the engine is worn to the point of needing internal repairs.

2. Ask students: What types of questions might you ask a customer to help determine whether there is an engine performance problem?

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Be aware of moving components in the engine compartment. Be aware of hot engine components.
3. Engine Compression	3. Engine compression is the pressure created in the engine during the compression stroke when the piston compresses the air/fuel mixture. In a four-stroke cycle, each stroke affects the other. Low compression has a major effect on power output. Must have a good sealing container.
4. Test Tools	4. Compression test kit Oil squirt can Battery charger Remote starter
5. Performing Cylinder Compression Test	5. Test is performed to check two main components for their sealing capability: valves and piston rings. Follow procedure sheet per manufacturer's recommendations.

Presentation Outline	Steps to Cover/Key Points to Make
	General procedure: ◆ Warm engine (thermostat open to normal operating temperature). ◆ Place transmission in PARK or NEUTRAL, apply parking brake, and block drive wheels. ◆ Disable vehicle from starting. ◆ Hook up battery charger, and place on low. ◆ Install remote starter ◆ Remove all spark plugs. (It's very helpful to label each spark plug wire. You can use clothes pins with cylinder ID info written on the ends.) ◆ Block the throttle wide open to allow maximum air flow into each cylinder. ◆ Install compression gauge kit in #1 spark plug hole. ◆ Crank engine required number of revolutions or gauge needle "jumps" per manufacturer's guidelines (e.g., minimum of 5 seconds). ◆ Repeat procedure for each cylinder. ◆ Record gauge readings for each cylinder as tested.
6. Analyzing Results/Performing Wet Test	6. Compare results to manufacturer's specifications. If reading is still low (e.g., below 100 psi or more than 10%), do the following: ◆ Remove tester. ◆ Add approximately 1 tsp of motor oil to the cylinder. ◆ Repeat test. ◆ Note reading.

Presentation Outline	Steps to Cover/Key Points to Make
7. Determining Needed Repairs	7. Possible Diagnoses If low reading rises after oil is added: • Rings not sealing If reading doesn't come up: • Valve, head, or gasket problem If two cylinders side-by-side are low: • Head or gasket problem If all cylinders are low (blow 100psi): • Worn engine • Incorrect valve timing

> ***Note:*** The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.
>
> For example, the applied mathematics teacher could deal with bore and stroke and the volume of air in the cylinder.

Review:

Ask students review questions such as the following:

1. What effect does poor (low) compression have on an engine?
2. Why is it important to have the engine at normal operating temperature prior to performing the compression test?

Application:

1. As students practice performing cylinder compression tests, quiz them individually on the process (e.g., ask them to explain how to keep the spark plug wires in order while disconnecting them).
2. Have students prepare a readings sheet and then use it to record findings during the compression test.

Evaluation:

√ Each student will perform a cylinder compression test and determine needed repairs. His/her performance will be evaluated using a copy of the performance checklist for Competencies 1.1.7/8.1.7.

Competencies 1.1.7/8.1.7: Perform cylinder compression tests; determine needed repairs

Performance Checklist

In performing a cylinder compression test and determining needed repairs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Ensured that engine was at normal operating temperature	☐	☐	☐	☐	☐
5. Performed cylinder compression test in accordance with service procedures, including:					
a. removed and labeled all spark plugs	☐	☐	☐	☐	☐
b. held throttle wide open for maximum air flow	☐	☐	☐	☐	☐
c. stabilized vehicle (e.g., parking brake on)	☐	☐	☐	☐	☐
d. disabled ignition system	☐	☐	☐	☐	☐
e. cranked engine required number of revolutions or gauge needle "jumps"	☐	☐	☐	☐	☐
6. Recorded readings for each cylinder	☐	☐	☐	☐	☐
7. Analyzed test results by comparing readings to manufacturer's specifications	☐	☐	☐	☐	☐
8. Ran a "wet test" on low cylinders	☐	☐	☐	☐	☐
9. Determined needed repairs	☐	☐	☐	☐	☐
10. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Units 1/8: Engine Repair/Engine Performance

Subunits 1.1/8.1: General Engine Diagnosis; Removal and Reinstallation (R & R)

Competencies 1.1.8/8.1.8: Perform cylinder leakage tests; determine needed repairs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Perform a cylinder leakage test and determine needed repairs
Criteria:	In accordance with the criteria in the checklist for Competencies 1.1.8/8.1.8

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when performing cylinder leakage tests and determining needed repairs. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Let's assume you are trying to identify the cause(s) of engine performance problems. You perform a cylinder compression test and note a loss of compression. Where did it go?
2. You need to check inside the engine to pinpoint exactly what is causing the loss of compression. This is the time to perform a cylinder leakage test.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Use caution when working on a warm engine; components may be ***hot***. Be aware of moving components in the engine compartment when shop air is connected to the tester.
3. Identifying Source of Compression Loss	3. Possible places to lose compression: valves, rings, head gasket, or intake gasket Poor maintenance is usually the cause of the problem (wear).
4. Cylinder Leakage Tester	4. Description Operation
5. Performing Cylinder Leakage Test	5. Always follow vehicle manufacturer's guidelines and tester manufacturer's instructions when performing the test. Hookup procedure: • Place vehicle in NEUTRAL (standard transmission) or PARK (automatic transmission. • Remove spark plugs. • Make sure cylinder is near BOC compression stroke. • Install test kit in spark plug hole. • Hook up air supply.

Presentation Outline	Steps to Cover/Key Points to Make
	Testing procedure:
	• With radiator cap off, run engine until it reaches its normal operating temperature (when the thermostat opens, coolant flows into radiator). ***Leave the cap off during the test.***
	• Bring the Number 1 cylinder up to TDC (compression stroke).
	• Calibrate tester per instructions.
	• Install tester in cylinder per instructions.
	• Note and record the "% Leakage" reading.
	Repeat this procedure for each cylinder. (***Note:*** each cylinder must be brought up to its TDC compression prior to the test.)
	Readings of a certain percentage (e.g., 10%) or greater indicate a problem. Check manufacturer's specifications for specific percentage.
	Check (listen to) all areas where leaks can occur:
	• Tailpipe—exhaust valve
	• Intake/carburetor/throttle body—intake valve
	• PVC/Oil fill cap—piston rings
	• Bubbles in radiator—head or intake gasket, crack in block or cylinder head
	Note: Most vehicles (even new ones) will have leakage past the piston rings. Check manufacturer's specifications for leakage percentage that is generally acceptable (e.g., up to 20%).
6. Determining Needed Repairs	6. Using diagnostic information gathered, refer to service manuals to identify needed repairs.
	Possible Diagnoses
	If air is escaping from throttle:
	• Intake valve problem

Presentation Outline	Steps to Cover/Key Points to Make
	If air is escaping from exhaust: • Exhaust valve problem If air is escaping from oil cap: • Ring problem If air is escaping from radiator: • Head gasket problem • Cracked head

> ***Note:*** The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.
>
> For example, the applied science teacher may help students with analysis of compression.

Review:

Ask students review questions such as the following:

1. In what locations inside the engine would you find "cylinder leakage"?
2. What potential problems may be caused when air is heard coming out of the exhaust tailpipe during the cylinder leakage test?
3. What percent cylinder leakage indicates a bad cylinder?
4. If you see bubbles in the radiator during the cylinder leakage test, what should this alert you to?

Application:

1. Have students develop a chart listing where leaks are heard on a vehicle (Column 1) and the possible causes for each (Column 2). This can be done on an individual, small-group, or whole-class basis.
2. Assign selected students to present an overview to the class of the procedure for performing the cylinder leakage test.

Evaluation:

√ Each student will perform a cylinder leakage test and determine needed repairs. His/her performance will be evaluated using a copy of the performance checklist for Competencies 1.1.8/8.1.8.

Competencies 1.1.8/8.1.8: Perform cylinder leakage tests; determine needed repairs

Performance Checklist

In performing a cylinder leakage test and determining needed repairs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Warmed up the engine to normal operating temperature	☐	☐	☐	☐	☐
5. Kept radiator cap off during both warm up and testing	☐	☐	☐	☐	☐
6. Brought Number 1 cylinder up to TDC	☐	☐	☐	☐	☐
7. Calibrated tester per instructions	☐	☐	☐	☐	☐
8. Installed tester in cylinder per instructions	☐	☐	☐	☐	☐
9. Recorded "% Leakage" reading correctly	☐	☐	☐	☐	☐
10. Repeated procedure for each cylinder	☐	☐	☐	☐	☐
11. Identified possible problem areas through analysis of results	☐	☐	☐	☐	☐
12. Listened to areas where leaks could occur	☐	☐	☐	☐	☐
13. Determined needed repairs	☐	☐	☐	☐	☐
14. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name______________________________________**Date**______________

Units 1/8: Engine Repair/Engine Performance

Subunits 1.2/8.11: Cylinder Head and Valve Train Diagnosis and Repair/Engine Related Service

Competencies 1.2.13/8.11.1: Adjust valves on engines with mechanical or hydraulic lifters

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Adjust valves on engines with mechanical and hydraulic lifters
Criteria:	In accordance with the criteria in the checklist for Competencies 1.2.13/8.11.1

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when adjusting valves on engines with mechanical and hydraulic lifters. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Valves must be adjusted periodically as part of a vehicle's maintenance schedule or after repairs have been made to the cylinder head or valve train areas of an engine.

2. Explain why it is essential to the operation of the engine that the valves be adjusted with precision in accordance with the manufacturer's specific procedures and specifications.

3. Briefly discuss the difference between valves with mechanical and hydraulic lifters.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Importance of Timing	2. Valves and pistons ***must*** be synchronized for proper engine operation.
3. Valve Noise	3. Possible causes: • Faulty adjustment • Worn rocker arms • Bent pushrod or bad camshaft
4. Preparation	4. Warm engine. Remove valve covers. Install splatter shields.

Presentation Outline	Steps to Cover/Key Points to Make
5. Adjusting Valves with Mechanical Lifters	5. Mechanical lifters usually require adjustment in accordance with the vehicle maintenance schedule. Manufacturer's procedures should be followed to the letter, using correct tools and specifications. General procedure: • Start engine. • Use feeler gauge to determine the clearance between the rocker arm and valve stem. • Adjust clearance in accordance with manufacturer's specifications. ***Note:*** On some vehicles, the valve/tappet cover gasket is ***reusable***.
6. Adjusting Valves with Hydraulic Lifters	6. Hydraulic lifters usually require adjustment only as result of a repair (they were developed to ***lessen*** maintenance costs and noise). Manufacturer's procedures should be followed to the letter, using correct tools and specifications. General procedure: • Start engine. • Loosen rocker arms until they clatter. • Tighten the rocker arms, one at a time, in accordance with manufacturer's specifications. ***Note:*** On some vehicles, the valve/tappet/rocker cover gasket is ***reusable***.
7. Consequences of Incorrect Adjustment	7. Too tight: • Miss in motor • Valves not closing totally Too loose: • Noise in motor • Valves not opening totally
8. Maintaining Clean Work Area	8. Clean all spilled oil, gasket materials, and debris out of the engine area.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could work with students on cam timing and number of degrees (duration) valve is open or closed..

Review:

Ask students review questions such as the following:

1. Why is the hydraulic valve more popular than the mechanical valve with most manufacturers?
2. If a valve is out of adjustment, what are the symptoms?
3. Why is proper clearance of valve train components important to efficient engine operation?
4. Why do hydraulic lifters not need to be adjusted ***periodically*** as mechanical lifters do?
5. Which type of valve is adjusted using a feeler gauge: mechanical or hydraulic?
6. True or False: If there is excessive valve lash, it means that the valve was adjusted too tight.

Application:

1. Have students prepare a table to guide diagnosis in the shop. For example, in one column, they could list all possible symptoms resulting from a valve that is adjusted too tight. In another column, they could list all possible causes of valve noise.
2. Have students prepare a procedure sheet for adjusting mechanical valves on a given vehicle (as specified by instructor) that can be used to guide student practice in the lab. This can be done on an individual, small-group, or whole-class basis.
3. Have students prepare a procedure sheet for adjusting hydraulic valves on a given vehicle (as specified by instructor) that can be used to guide student practice in the lab. This can be done on an individual, small-group, or whole-class basis.

Evaluation:

√ Each student will adjust valves on engines with mechanical and hydraulic lifters. His/her performance will be evaluated using a copy of the performance checklist for Competencies 1.2.13/8.11.1.

Competencies 1.2.13/8.11.1: Adjust valves on engines with mechanical or hydraulic lifters

Performance Checklist

In adjusting valves on engines with mechanical and hydraulic lifters, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Followed preparation procedures appropriate for type of valve	☐	☐	☐	☐	☐
5. Adjusted mechanical/hydraulic lifters in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
6. Performed visual inspection of hydraulic lifters:					
a. Checked fluid level	☐	☐	☐	☐	☐
b. Checked condition of surfaces	☐	☐	☐	☐	☐
c. Replaced valve cover gasket if needed	☐	☐	☐	☐	☐
d. Checked for leaks	☐	☐	☐	☐	☐
e. Checked tightness of fasteners/fittings	☐	☐	☐	☐	☐
7. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 1: Engine Repair

Subunit 1.3: Engine Block Diagnosis and Repair

Competency 1.3.3: Inspect internal and external threads; repair as needed

Competency Development Guide

Objective:

Condition:	Provided with an engine or necessary components and service information, and while following all applicable safety guidelines
Behavior:	Inspect internal and external threads, and repair them as needed
Criteria:	In accordance the criteria in the checklist for Competency 1.3.3

Introduction:

General Introductory Techniques: Share personal experiences you have had when inspecting and repairing internal and external threads in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. All threaded components—whether internal or external—need to be inspected in order to identify damage, corrosion, deterioration, and the like.
2. Once identified, these conditions can be repaired as necessary.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Small bits of dirt or metal can get into your eyes or skin; be very aware of such hazards.
3. Key Terms	3. Internal threads are those ***inside*** the bolt's hole. A *tap* is the tool used to cut or clean up an internal thread External threads are those ***outside*** the fastener. A *die* is the tool used to cut or clean up an external thread. Illustrations/actual examples of each
4. Importance of Oiling Tools	4. When cutting new threads or repairing damaged ones, ***always use oil.*** It will help the tool do its job and will help the tool last.

Presentation Outline	Steps to Cover/Key Points to Make
5. Cleaning Tools	5. Always "back off" each of these tools after making a one-half to full turn so it can clean out any debris between the tool and the threads. This will also improve the cut/clean and lengthen the tool's life. Before putting these tools away, wash off each in the cleaning solvent and dry to get out any and all debris for the next use. Clean each tool out between each use, especially when cleaning out internal threads in the block as well as the block holes.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could cover metric and standard conversion charts, how to read a ruler, and thread size (coarse, fine).

Review:

Ask students review questions such as the following:

1. What tools are used to cut internal and/or external threads?
2. Which type of tap would be best for cleaning out a cylinder head bolt hole?
3. Why should you always wear eye protection when using thread-repair tools?
4. What process should be used to clean out a thread-repair tool as you are using it?

Application:

1. Have students identify types of taps and dies (e.g., size them to a thread).
2. Provide students with a soft metal (1/2"-thick aluminum is good). Have them select a bolt size, correct drill bit and tap to use, and then drill and tap a hole to correct size for that bolt. Finally, have them install bolt and tighten it to test the new thread's strength.

Evaluation:

√ Each student will inspect internal and external threads and repair them as needed. His/her performance will be evaluated using a copy of the performance checklist for Competency 1.3.3.

Competency 1.3.3: Inspect internal and external threads; repair as needed

Performance Checklist

In inspecting and repairing internal and external threads, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Inspected internal and external threads	☐	☐	☐	☐	☐
5. Identified poor thread-to-thread contact (e.g., due to corrosion, rust, stripping, dirt)	☐	☐	☐	☐	☐
6. Completed repairs in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
7. Kept tool(s) lubricated with oil when cutting new threads or repairing damaged ones	☐	☐	☐	☐	☐
8. Backed off each tool after making one-half to full turn to clean out debris between tool and threads	☐	☐	☐	☐	☐
9. Cleaned tool(s) between each use and at end of job	☐	☐	☐	☐	☐
10. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**_____________

Unit 1: Engine Repair

Subunit 1.3: Engine Block Diagnosis and Repair

Competency 1.3.18: Prime engine lubrication system

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or necessary components and service information, and while following all applicable safety guidelines
Behavior:	Prime an engine lubricating system
Criteria:	In accordance with the criteria in the checklist for Competency 1.3.18

Introduction:

General Introductory Techniques: Share personal experiences you have had when priming engine lubrication systems in the auto tech shop. Show videos that demonstrate the steps in this process.

Competency-Specific Information:

1. Assume that your engine is well on its way to completion, and you have spent many long hours making sure all is correct inside there.

2. In order to help get lubrication to ***all*** critical parts, you must at some point "prime" that engine's lubrication system. If it starts and has ***no oil pressure***, all that you did to make the engine "young" again has now been undone.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Priming: Definition and Purpose	2. *To prime* is to spread the necessary lubricant around to all the areas in which it is needed ***before*** trying to start the engine. Priming is necessary in order to make sure there are no parts moving without lubrication. If they did, they could be permanently damaged in a matter of a few seconds, and the engine rebuild you just performed could be ruined.
3. Steps in Priming Under Pressure	3. The easiest way to prime the engine lubrication system is to use a lubrication system pressurizer. Follow the manufacturer's instructions on how to use your specific pressurizer. Fill pressurizer with the same oil you will use in the system. Pressurize the tool up to (***no greater than***) the normal oil pressure for your engine. Attach the tool's hose fitting to an oil gallery point (usually it is best to use the oil sender port because it comes right from the oil pump itself). Open the tool's valve, allowing oil under pressure to travel to the pump, oil galleys, lifters, all bearing surfaces, and other critical components requiring lubrication.

Presentation Outline	Steps to Cover/Key Points to Make
	Rotate the engine ***by hand*** several revolutions while the tool is priming the system to make sure all parts get complete lubrication.
4. Alternative Approach	4. Some distributor-driven, oil pump-type engines can be primed using a special tool (or an old distributor shaft that has been modified to fit) and a drill. Run drill with tool installed until desired pressure is obtained on gauge. Do not forget to ***also*** rotate engine ***by hand*** several revolutions to spread the lube around correctly and completely.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could provide information on oil viscosity.

Review:

Ask students review questions such as the following:

1. Which engine components require lubrication ***under pressure***?
2. What possible failures could a lack of proper lubrication cause, and why?
3. Why is it important to rotate the engine by hand when priming an engine lubrication system?
4. True or False: The oil placed on parts when assembled will provide adequate lubrication when the engine is first started.

Application:

1. Assign students specific vehicles, and have them identify the correct type and weight of oil for each vehicle.
2. Have students practice performing oil lubrication system priming on three different vehicle engine assemblies.

Evaluation:

√ Each student will prime an engine lubrication system. His/her performance will be evaluated using a copy of the performance checklist for Competency 1.3.18.

Competency 1.3.18: Prime engine lubrication system

Performance Checklist

In priming an engine lubricating system, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Primed engine lubrication system using specified equipment (or distributor shaft and drill) per manufacturer's procedure	☐	☐	☐	☐	☐
5. Primed using same oil that would be used in system	☐	☐	☐	☐	☐
6. Rotated engine by hand several revolutions while using tool	☐	☐	☐	☐	☐
7. Ensured that all parts received complete lubrication	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name_______________________________________**Date**_____________

Units 1/7/8: **Engine Repair/Heating and Air Conditioning/Engine Performance**

Subunits 1.4/7.4./8.11: Lubrication and Cooling Systems Diagnosis and Repair/ Heating and Engine Cooling Systems Diagnosis and Repair/ Engine Related Service

Competency 1.4.3	Perform cooling system tests (pressure, combustion, leakage, and temperature); determine needed repairs
Competency 7.4.2	Perform cooling system, cap, and recovery system tests (pressure, combustion, leakage, and temperature); determine needed repairs
Competency 8.11.3	Verify engine operating temperature; determine needed action
Competency 8.11.4:	Perform cooling system pressure tests; check coolant condition; inspect and test radiator, pressure cap, coolant recovery tank, and hoses; service or replace as needed

Competency Development Guide

Objective:

Condition: Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines

Behavior: Perform cooling system tests, and determine needed repairs

Criteria: In accordance with the criteria in the checklist for Competencies 1.4.3/7.4.2/ 8.11.3/8.11.4

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when performing cooling system tests and determining needed repairs. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. A cooling system is very important to engine performance and to the engine's service life.

2. Without proper cooling, an engine can suffer severe damage in just a manner of minutes.

3. Antifreeze is important in warm weather as well as cold. In warm weather, it provides improved cooling.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Be always aware of moving parts (e.g., fan blades, pulleys, belts). Radiator coolant is under pressure in a running engine, and it is ***hot***. If you try to take off the radiator cap while the engine is hot, the release of pressurized liquid can make the coolant boil and expand. If allowed to spurt out of the radiator filler neck area, boiling coolant can cause ***severe burns***.
3. System Components	3. Characteristics/operation of the following: • Radiator • Thermostat • Heater core • Hoses • Pump • Radiator pressure cap Examples of worn components Problems that might occur as a result of the wear

Presentation Outline	Steps to Cover/Key Points to Make
4. Performing Pressure Test	4. This test is used to quickly locate the source of coolant leakages. The *pressure tester* is a hand-operated air pump, which forces compressed air onto the coolant. General procedure: • Remove radiator pressure cap (with car at normal operating temperature). • Check coolant level. • Use antifreeze hydrometer to test freeze protection level of coolant. • Wipe inside of filler neck; check for damage inside sealing seat. • Inspect overflow tube for dents, kinks, or obstructions. • Inspect cams on outside of filler neck; reform any bent cams. • Install the tester on the radiator filler neck, in place of the radiator cap. • Using manufacturer's specifications, pump the tester until the gauge on the tester reaches the correct pressure (generally in the 14–16 psi or 96 kPa range). ***Caution:*** Do not over-pressurize the system beyond the specifications because you could cause a component to rupture. The gauge pressure should hold for at least 3 minutes steady. Document any drop of pressure seen. Interpret reading: • If pressure holds • If pressure drops quickly • If pressure drops slowly Visually inspect all parts (hose fittings, clamps, radiator, water pump, intake manifold, cylinder head-to-block contacts, core plugs, heater core, etc.) for coolant leakage.

Presentation Outline	Steps to Cover/Key Points to Make
5. Performing Combustion Leak Test	5. This test is used to check for the presence of combustion chamber gases in the coolant. It should be performed when you have signs that point to a blown head gasket, cracked block, or cracked cylinder head (e.g., overheating, bubbles in coolant, a rise in coolant level when starting the engine). Put the *combustion leak tester* onto the radiator filler neck. Run the engine; then squeeze the tester bulb and release. This draws air through the test fluid. The test fluid (usually blue) will change to a yellow color if any combustion gases are leaking into the engine coolant. If the fluid stays blue, there is no combustion leak into the coolant. If a leak is indicated, short out the cylinders one at a time (***no longer than 15 seconds*** so as not to damage the catalytic converter). When the fluid does not change its color, you have found your leaking cylinder(s). Another method is to use an exhaust gas analyzer
6. Alternative Method for Performing Combustion Leak Test	6. This method uses an exhaust gas analyzer. Remove the radiator cap, and place a tail pipe probe over the neck. Accelerate the engine, and watch the hydrocarbon (HC) meter. If the meter reads, you have a leak.
7. Engine Overheating	7. Average operating temperature of an engine (around 230°) Importance of maintaining normal operating temperature in terms of engine operation and emissions Reasons why an engine may overheat

Presentation Outline	Steps to Cover/Key Points to Make
8. Performing Temperature Test	8. Remove radiator cap, and insert coolant thermometer into the neck. Run engine for up to 10 minutes, and note temperature while looking for coolant flow through radiator tubes. Temperature should be approximately 10%–15% above the thermostat rating of the engine. If the temperature is too high, locate causes of excess heat: • Feel upper radiator hose, checking for excessive temperature and/or gurgling. • Check coolant recovery tank for proper level. If the temperature is too low, suspect open thermostat, locked fan clutch, or electric fan running constantly.
9. Alternative Method for Performing Temperature Test	9. Tempsticks give a quick and fairly accurate diagnosis of thermostat operation without having to remove it. They are made of wax, one melting at about 188°F, the other at about 202°F. First, draw a short line on the thermostat housing with the 188° stick (one color). Using the 202° stick (which is another color), draw another line parallel to the 188° line and about 1/2" away. As the thermostat begins to open, the 188° line should melt. As the engine reaches operating temperature (thermostat fully open), the 202° line should melt.
10. Determining Needed Repairs	10. Using diagnostic information gathered, refer to service manuals to identify needed repairs.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could cover the composition of antifreeze, hazards related to handling antifreeze, and how coolant operates at different temperatures (230°F and 212°F).

Review:

Ask students review questions such as the following:

1. Describe safety concerns that apply to servicing/diagnosing the cooling system.
2. If you over-pressurize the radiator and cooling system during a pressure test, what could be the consequence?
3. When you hear the expression, "the engine's normal operating temperature," what range do you think that means?
4. What types of damage could occur as a result of an overheating engine?
5. What effect does one pound of pressure have on the boiling point of coolant?
6. True or False: The proper proportion of antifreeze to water is 20:40.

Application:

1. Give students a diagram of a cooling system, and have them indicate the potential trouble spots.
2. Have students use the textbook and service manuals to identify and define cooling system vocabulary terms. This can be done on an individual or small-group basis.
3. Give students a written case study describing a specific overheating problem, and have them troubleshoot that problem.
4. As students practice pressure testing the coolant system, quiz them individually on the process (e.g., ask them to explain how to locate leaks).
5. Create leaks in a coolant system (e.g., by loosening the clamps), and have students use the appropriate checks and tests to locate the problem.

Evaluation:

√ Each student will perform cooling system tests and determine needed repairs. His/her performance will be evaluated using a copy of the performance checklist for Competencies 1.4.3/7.4.2/8.11.3/8.11.4.

Competency 1.4.3	Perform cooling system tests (pressure, combustion, leakage, and temperature); determine needed repairs
Competency 7.4.2	Perform cooling system, cap, and recovery system tests (pressure, combustion, leakage, and temperature); determine needed repairs
Competency 8.11.3	Verify engine operating temperature; determine needed action
Competency 8.11.4:	Perform cooling system pressure tests; check coolant condition; inspect and test radiator, pressure cap, coolant recovery tank, and hoses; service or replace as needed

Performance Checklist

In performing cooling system tests and determining needed repairs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Selected appropriate equipment for performing cooling system pressure test	☐	☐	☐	☐	☐
5. Performed cooling system pressure test in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
6. Determined needed repairs	☐	☐	☐	☐	☐
7. Selected appropriate equipment for performing cooling system combustion leakage test	☐	☐	☐	☐	☐
8. Performed cooling system combustion leakage test in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
9. Determined needed repairs	☐	☐	☐	☐	☐
10. Selected appropriate equipment for performing cooling system temperature test	☐	☐	☐	☐	☐
11. Performed cooling system temperature tests in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
12. Determined needed repairs	☐	☐	☐	☐	☐
13. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**_______________

Unit 1: Engine Repair

Subunit 1.4: Lubrication and Cooling Systems Diagnosis and Repair

Competency 1.4.4: Inspect, replace, and adjust drive belts and pulleys

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Inspect, replace, and adjust drive belts and pulleys
Criteria:	In accordance with the criteria in the checklist for Competency 1.4.4

Introduction:

General Introductory Techniques: Share personal experiences you have had when inspecting, replacing, and adjusting drive belts and pulleys in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Slipping belts will make noise or cause an accessory to fail to work according to recommended specifications.
2. Broken belts will cause inoperative components, and engine damage may occur quickly.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Belt Inspection Process	2. Belt problems include cracks, glazing, splits/tears, and wear. Usually these problems are easily identified through a simple visual check. Oil-soaked belts appear a bit darker in color than their mates. (Be sure to locate and repair the sources of the oil leaks as well.) Examples of belts with and without problems
3. Pulley Inspection Process	3. Pulley problems include pits, cracks, rust, oil, etc., both in pulley grooves and around the entire pulley. These problems can also be identified by a simple visual check. Also inspect pulley mountings for proper tightness. Pulley alignment is necessary for belt life and proper performance. Use a straightedge to align pulleys to manufacturer's specifications (e.g., within 1/16" per foot of distance across the faces of all pulleys having the same belt). Diagrams of misaligned pulleys

Presentation Outline	Steps to Cover/Key Points to Make
4. Belt Replacement/Adjustment Process	4. Usually it is recommended that you replace all belts when one is found to be bad. Follow all manufacturer's recommended procedures and specifications. Be sure to use proper tools to pry with, and pry only in recommended locations so you don't damage other components. Make sure tension meet's manufacturer's specifications. Some belts stretch when new, so ask customer to come back in after about 5,000 miles so the belt can be retightened. Belts with automatic tensioners will not require such readjustment.
5. Pulley Replacement Process	5. ***Key point:*** Follow manufacturer's instructions and procedures exactly; do not take shortcuts or you may cause yourself grief. Be sure to tighten all fastener's to manufacturer's specifications.
6. Building Customer Trust and Goodwill	6. The customer pays you for service—good service! What does this mean? ◆ Some auto technicians provide readjustment of new belts after 5,000 miles at no charge. ◆ It's a good idea to check the accessories themselves while looking at belts and pulleys. You may find a problem that can be corrected before the customer is stranded.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could discuss types of bearings (ball, roller, needle) and the effect of lateral pressure on a bearing.

Review:

Ask students review questions such as the following:

1. Why is it recommended that you replace all drive belts when one fails?
2. If a belt is too loose, what could happen?
3. If the belt is glazed, does this indicate that it is correctly grabbing the pulley groove(s)? Why or why not?
4. If there is a crack in the belt pulley, what will this do to the belt?

Application:

1. Give students a written case study describing a belt noise, and have them explain what to look for and what repairs to recommend.
2. As students practice inspecting, replacing, and adjusting drive belts and pulleys, quiz them individually on the process (e.g., ask them to identify causes of belt failures).

Evaluation:

√ Each student will inspect, replace, and adjust drive belts and pulleys. His/her performance will be evaluated using a copy of the performance checklist for Competency 1.4.4.

Competency 1.4.4: Inspect, replace, and adjust drive belts and pulleys

Performance Checklist

In inspecting, replacing, and adjusting drive belts and pulleys, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Inspected drive belts in accordance with procedure	☐	☐	☐	☐	☐
5. Identified all belt problems (e.g., cracks, glazing, splits/ tears, wear)	☐	☐	☐	☐	☐
6. Inspected pulleys in accordance with procedure	☐	☐	☐	☐	☐
7. Identified all pulley problems (e.g., pits, cracks, rust, oil in grooves, improper tightness)	☐	☐	☐	☐	☐
8. Determined needed repairs	☐	☐	☐	☐	☐
9. Adjusted drive belts/pulleys in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
10. Tightened all fastener's to manufacturer's specifications	☐	☐	☐	☐	☐
11. Performed final visual inspection	☐	☐	☐	☐	☐
12. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 1: Engine Repair

Subunit 1.4: Lubrication and Cooling Systems Diagnosis and Repair

Competency 1.4.14: Perform oil and filter change

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Perform an oil and filter change
Criteria:	In accordance with the criteria in the checklist for Competency 1.4.14

Introduction:

General Introductory Techniques: Share personal experiences you have had when changing oil and oil filters in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Vehicle owners need to be encouraged to follow the recommended maintenance schedule in order to keep their vehicles in good running order.
2. The ***main*** maintenance service that should be performed is to change the engine oil and filter on a regular basis (in accordance with the manufacturer's recommendations).

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. ***Remember:*** The oil is very ***hot***, as are its related engine components. ***Always*** make sure the vehicle is safely positioned on the lift prior to beginning your work.
3. Draining the Old Oil	3. Gather correct tools and materials for the job. Place drain receptacle under the oil pan drain plug. Loosen the drain plug using the correct wrench. Once loose, quickly remove the plug, allowing the oil to drain from the oil pan. ***Caution:*** The oil will usually be hot. Make sure the drain receptacle is positioned so that ***all*** oil is caught. ***Key point:*** Any oil that spills must be cleaned up as soon as possible to avoid a slip/trip/fall hazard.

Presentation Outline	Steps to Cover/Key Points to Make
4. Changing the Oil Filter	4. While the oil is draining, loosen the oil filter using the correct tool. Remove the filter. Place the removed filter upside down in the receptacle to drain all the oil out. (Filter should be discarded according to local environmental guidelines and regulations.) Wipe clean the oil filter mounting surface on the engine block, and remove the old filter's seal from the block. Apply a film of clean oil to the new filter's rubber seal in order to ease its removal next time. Install and ***hand-tighten*** the new filter in accordance with the manufacturer's specifications. ***Key point:*** Not all filters use the same installation procedure. Follow each prescribed step for the filter you are using. Otherwise, you may create leaks, or worse.
5. Replacing the Oil Pan Drain Plug	5. Prior to installing the drain plug, wipe it off and look at its gasket (if it has one). If the gasket is cracked or damaged, replace it. ***Remember:*** If there are oil leaks after you have performed the oil change, it will not do a lot of good for your reputation. Install and tighten the drain plug in accordance with the manufacturer's specifications. ***Key point:*** If you undertighten, there may be oil leaks. If you overtighten, thread damage can occur.

Presentation Outline	Steps to Cover/Key Points to Make
6. Adding New Oil and Checking the Job	6. Lower the vehicle carefully. Remove the oil filter cap on the engine, and carefully fill the engine crankcase with the proper oil in the correct quantity. Start the engine, check that you have oil pressure, and inspect for leaks at the plug and filter. Stop the engine, recheck the oil level with the dipstick, and add to the FULL mark if necessary.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could cover the torque of bolts and nuts, levers, and pressure (work out = work in).

Review:

Ask students review questions such as the following:

1. What is the ***best*** way for an owner to determine when (how often) to have the oil and filter changed in his or her vehicle?
2. Where should you look to find out what type of oil to use and how much to use in performing an oil change?
3. Why should you remove the old filter seal from the block before installing a new filter?
4. Describe places where you should check for engine oil leaks after you have finished changing the oil and filter.

Application:

1. Have students interview relatives or neighbors to determine the concerns they have about oil changes.
2. Assign students to small groups, and have each group determine the weights of various oils and their applications.

Evaluation:

√ Each student will perform an oil and filter change. His/her performance will be evaluated using a copy of the performance checklist for Competency 1.4.14.

Competency 1.4.14: Perform oil and filter change

Performance Checklist

In performing an oil and filter change, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Performed oil change in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
5. Performed filter change in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
6. Performed visual inspection, as follows:					
a. checked fluid type	☐	☐	☐	☐	☐
b. checked fluid level	☐	☐	☐	☐	☐
c. checked for leaks	☐	☐	☐	☐	☐
d. checked tightness of drain plug and filter	☐	☐	☐	☐	☐
7. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name_______________________________________**Date**______________

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"Automatic Transmission
and Transaxle"
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Unit 2: Automatic Transmission and Transaxle

Subunit 2.1: General Transmission and Transaxle Diagnosis

Competency 2.1.1:	Interpret and verify driver's complaint; verify proper engine operation; determine needed repairs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle, a customer, and service manuals; and while following all applicable safety guidelines
Behavior:	Determine needed repairs for a vehicle whose driver describes problems that seem to relate to the transmission/transaxle
Criteria:	In accordance with the criteria in the checklist for Competency 2.1.1

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop in dealing with customers whose vehicles seem to have transmission/transaxle problems and determining needed repairs. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Two-thirds of consumer complaints deal with the automobile. If you want to develop the skills necessary to be financially successful in the automotive field, you must be willing to listen to the customers.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Interpreting Customer Complaints	2. Interview the customer in order to identify the problem. Diagnose and verify the problem, then suggest a solution. The customer has the right to accept or refuse the solution you offer.
3. Verifying Proper Engine Operation	3. Some customer complaints about transmission/transaxle operation may in fact be due to an engine problem; for example: ◆ Torque converter clutch systems may have a chuggle, or the engine may miss at certain speeds. ◆ The car does not shift into high. Low vacuum from the engine may affect transmission modulator valve.
4. Verifying Problem	4. One method for verifying that the problem exists is to test-drive the vehicle. ***Note:*** If program guidelines do not allow the use of this method, the instructor will need to test-drive the vehicle and provide feedback to the students. Another method is to make a visual examination of the vehicle, focusing on the problem areas identified.

Presentation Outline	Steps to Cover/Key Points to Make
5. Determining Needed Repairs	5. Using diagnostic information gathered, refer to service manuals to identify needed repairs.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied communication teacher can have students participate in role-playing situations between a technician and a customer trying to describe his or her vehicle problems.

Review:

Ask students review questions such as the following:

1. What types of engine problems can affect transmission operation?
2. Should you accept a customer's solution to his/her problem? Why or why not?
3. If you accept the customer's solution, what should you do if what the customer wants you to do is wrong?

Application:

1. Have students practice interpreting and verifying customer complaints using role-playing (one student as customer, one student as technician). Have each student serve at least once in each role, if possible.
2. Divide students into small groups, and give each student in the group only one piece of diagnostic information. This will force students in the group to talk with each other and cooperate in order to identify the needed repair.
3. Give students a variety of diagnostic information, and ensure that some of the information is ***not*** applicable to the problem. Have them determine needed repairs using a service manual.

Evaluation:

√ Each student will determine needed repairs for a vehicle whose driver describes problems that seem to relate to the transmission/transaxle. His/her performance will be evaluated using a copy of the performance checklist for Competency 2.1.1.

Competency 2.1.1: Interpret and verify driver's complaint; verify proper engine operation; determine needed repairs

Performance Checklist

In determining needed repairs for a vehicle whose driver describes problems that seem to relate to the transmission/ transaxle, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Used probing interview questions to help customer clearly describe problem	☐	☐	☐	☐	☐
4. Verified that problem was not related to improper engine operation	☐	☐	☐	☐	☐
5. Test-drove vehicle to verify problem (or secured feedback on test-drive from instructor)	☐	☐	☐	☐	☐
6. Performed complete visual inspection to verify problem	☐	☐	☐	☐	☐
7. Documented diagnostic information accurately	☐	☐	☐	☐	☐
8. Determined needed repairs using diagnostic information and appropriate service manuals/TSBs	☐	☐	☐	☐	☐
9. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**_____________

Competency 2.1.2: Diagnose unusual fluid usage, level, and condition problems; determine needed repairs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle with a transmission fluid defect and manufacturer's information, and while following all safety guidelines
Behavior:	Diagnose unusual fluid usage, level, and condition problems; and determine needed repairs
Criteria:	In accordance with the criteria in the checklist for Competency 2.1.2

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when diagnosing transmission fluid defects and determining needed repairs. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Explain that transmission fluid is what makes a transmission go. If it isn't there or it's in bad shape, the car won't go. Adding two quarts of this fluid may be the difference between being stopped at the side of the road and arriving at where you want to go.
2. Show students clutches out of an automatic transmission, and ask them what would happen to one of those clutches if it tried to drive a 4,000-pound car without any fluid.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. For some people, transmission fluid additives may cause a rash. Be sure that exhaust fans are hooked up when running a vehicle to check fluid levels.
3. Transmission Fluid	3. Functions: • Transfers hydrodynamic energy • Transfers heat • Lubricates transmission parts Properties: • Types (by application or vehicle make) • Recommended interval change • Amount in pan and amount in torque converter
4. Transmission Fluid Additives	4. Pros and cons
5. Lubrication Manuals	5. Procedure for checking for correct type and amount of fluid using a lubrication manual

Presentation Outline	Steps to Cover/Key Points to Make
6. Fluid Inspection	6. Conditions to watch for: • Burnt smell (indication of overheating) • Coolant in transmission fluid (raspberry milkshake color) • Discoloration • Aeration (foam)
7. Unusual Fluid Usage	7. Check for internal leakage at modulator valve.
8. Checking Fluid Level	8. Preparation: • Engine at normal operating temperature and running at slow idle • Vehicle level and parking brake on • Transmission in PARK Deployment procedure for taking dipstick reading of fluid level
9. Determining Needed Repairs	9. Using diagnostic information gathered, refer to service manuals to identify needed repairs.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could discuss what causes transmission oil to break down and lose its ability to lubricate.

Review:

Ask students review questions such as the following:

1. What are some of the pros and cons associated with automatic transmission fluid additives?
2. What are some of the indications that the transmission fluid is "bad"?

Application:

1. Give students lubrication manuals, and have them determine correct applications for several different vehicles.
2. As students practice diagnosing fluid problems, quiz them individually on the process (e.g., ask them to list the steps to follow in checking the transmission fluid in a vehicle).

Evaluation:

√ Each student will diagnose unusual fluid usage, level, and condition and determine needed repairs. His/her performance will be evaluated using a copy of the performance checklist for Competency 2.1.2.

Competency 2.1.2: Diagnose unusual fluid usage, level, and condition problems; determine needed repairs

Performance Checklist

In diagnosing fluid problems and determining needed repairs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Performed complete visual inspection to identify leaks	☐	☐	☐	☐	☐
5. Followed prescribed procedure for checking fluid level	☐	☐	☐	☐	☐
6. Obtained accurate fluid level reading	☐	☐	☐	☐	☐
7. Accurately diagnosed fluid condition	☐	☐	☐	☐	☐
8. Determined needed repairs	☐	☐	☐	☐	☐
9. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competency 2.1.3: Perform pressure tests; determine needed repairs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle, transmission pressure tester kit, and manufacturer's information; and while following all applicable safety guidelines
Behavior:	Pressure-test a transmission, and determine needed repairs
Criteria:	In accordance with the criteria in the checklist for Competency 2.1.3

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when pressure-testing a transmission and determining needed repairs. Show videos that demonstrate the steps in this process.

Competency-Specific Information:

1. One of the most frustrating experiences is to take a transmission apart and not be able to find what's wrong with it. There are a lot of nooks and crannies that can hide dirt that will prevent a certain clutch or band from being applied.

2. Therefore, the time to determine what's wrong with a transmission is *before* disassembling it. One method to use is a pressure check. Who knows, the pressure check may show you that you don't have to take the transmission apart at all.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Cautions related to— • running vehicle on lift • exhaust (removal system must be in place) • putting transmission in PARK when drive wheels are spinning • front-wheel drive vehicles (i.e., should not be run with constant velocity joints in the fully extended position)
3. Hydraulic Principles	3. Liquids can't be compressed. Pressure vs. force Hydraulic leverage
4. Hydraulic Valve Functions	4. Regulates flow and pressure. Directs flow and pressure. Directs and regulates flow and pressure.
5. Types of Valves	5. Check balls Orifice Spool valves Solenoids

Presentation Outline	Steps to Cover/Key Points to Make
6. Transmission Pressure & Valves	6. Oil pump Mainline pressure—pressure regulator valve Manual valve—shift linkage Modulator/throttle valve—engine load Governor valve—road speed Shift valves
7. Performing Pressure Test	7. Use of service manual to determine what each external hydraulic port checks Characteristics/operation of pressure tester Procedure for hooking up pressure tester and testing pressure for a specific vehicle Ensuring that hook-up is free of exhaust lines and any pinch points
8. Determining Needed Repairs	8. Using diagnostic information gathered, refer to service manuals to identify needed repairs.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could cover pressure (work in = work out).

Review:

Ask students review questions such as the following:

1. How can you determine where the pressure ports are and what each port checks?
2. In which gear do you get the highest readings? the lowest?
3. What are some safety factors to remember when performing a transmission pressure test?
4. How is fluid pressure maintained in an automatic transmission? What happens to pressure as you speed up? What happens to pressure as you go up a hill?

Application:

1. Give each student one application or model car with manual, and have them diagram the location of each hydraulic port and list what each hydraulic port checks.

2. Have students prepare procedure sheets on how to hook up the transmission oil pressure tester, including all safety issues related to the testing procedure.

Evaluation:

√ Each student will pressure-test a transmission and determine needed repairs. His/her performance will be evaluated using a copy of the performance checklist for Competency 2.1.3.

Competency 2.1. 3: Perform pressure tests; determine needed repairs

Performance Checklist

In pressure-testing a transmission and determining needed repairs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Located proper test port	☐	☐	☐	☐	☐
5. Installed gauge in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
6. Accurately determined pressure readings	☐	☐	☐	☐	☐
7. Accurately recorded pressure readings	☐	☐	☐	☐	☐
8. Determined needed repairs using recorded pressure readings and appropriate service manuals	☐	☐	☐	☐	☐
9. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name_______________________________________**Date**_____________

Unit 2: Automatic Transmission and Transaxle

Subunit 2.2: Transmission and Transaxle Maintenance and Adjustment

Competency 2.2.1: Inspect, adjust or replace manual shift valve and throttle (TV) linkages or cables and check gear select indicator (as applicable)

Competency Development Guide

Objective:

Condition:	Provided with a vehicle with a manual shift valve and throttle (TV) linkages or cables, basic hand tools, and service manuals; and while following all applicable safety guidelines
Behavior:	Inspect and adjust or replace manual shift valve and throttle (TV) linkages or cables, and check gear select indicator
Criteria:	In accordance with the criteria in the checklist for Competency 2.2.1

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when inspecting and adjusting or replacing manual shift valve and throttle (TV) linkages or cables and checking gear select indicators. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Give an example of what could happen if a technician removed a transmission from a vehicle, only to discover that all that was needed was a throttle linkage adjustment.

2. Give an example of what could happen if a technician started a vehicle that was supposed to be in PARK, only to discover that the vehicle is in gear.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Car must be in PARK; in any other gear, the vehicle can take off.
3. Gear Selection Cable or Linkage	3. Function Components Location
4. Need for Replacement	4. Binding Improper gear selection (where REVERSE, PARK, and DRIVE are located)
5. Throttle Linkage or Cable	5. Function (may be used only for downshift or may be used to determine throttle position) Components Location
6. Replacement and Adjustment	6. Proper adjustment for proper shift points Ensuring that engine throttle doesn't stick Removal of transmission pan (sometimes required)

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could discuss levers and mechanical advantage.

Review:

Ask students review questions such as the following:

1. What safety concerns are related to the replacement of a gear selector linkage and throttle valve linkage?
2. What are the two types of throttle linkages, and how do they differ?

Application:

1. Have students diagram the manual shift valve and throttle (TV) linkages or cables and label the parts.
2. As students practice servicing manual shift valve and throttle linkages or cables and checking the gear select indicator, quiz them individually on the process (e.g., ask them to briefly explain the purpose of a throttle shift cable on a vehicle that does not have a modulator valve or computer to determine engine throttle inputs).

Evaluation:

√ Each student will inspect and adjust or replace a manual shift valve and a throttle (TV) linkage or cable and check the gear select indicator. His/her performance will be evaluated using a copy of the performance checklist for Competency 2.2.1.

Competency 2.2.1: Inspect, adjust or replace manual shift valve and throttle (TV) linkages or cables and check gear select indicator (as applicable)

Performance Checklist

In servicing manual shift valve and throttle linkages or cables and checking gear select indicator, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Performed complete visual inspection of cable/linkages	☐	☐	☐	☐	☐
5. Determined need for replacement	☐	☐	☐	☐	☐
6. Adjusted cable/linkages in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
7. Visually inspected gear indicator for proper alignment	☐	☐	☐	☐	☐
8. Adjusted or replaced indicator as needed	☐	☐	☐	☐	☐
9. Performed final visual inspection	☐	☐	☐	☐	☐
10. Checked tightness of fasteners/fitting	☐	☐	☐	☐	☐
11. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 2: Automatic Transmission and Transaxle

Subunit 2.2: Transmission and Transaxle Maintenance and Adjustment

Competency 2.2.2:	Service transmission; perform visual inspection; replace fluids and filters

Competency Development Guide

Objective:

Condition:	Provided with an automotive vehicle transmission, basic hand tools, service manuals, transmission fluid, and a transmission filter kit; and while following all applicable safety guidelines
Behavior:	Inspect an automatic transmission, and replace fluids and filters
Criteria:	In accordance with the criteria in the checklist for Competency 2.2.2

Introduction:

General Introductory Techniques: Share personal experiences you have had when inspecting transmissions and replacing fluids and filters in the auto tech shop. Show videos that demonstrate the steps in this process.

Competency-Specific Information:

1. Describe how a simple check for low fluid or clogged filters can often get you back on the road when a transmission refuses to go.

2. Show students a service manual that recommends transmission service on a regular basis or never, and explain why.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Cautions related to hot fluid and dropping pans Slipperiness of transmission fluid compared to oil
3. Filters	3. Purpose Location
4. Fluids	4. Transmission fluids for particular makes/models of cars with automatic transmissions
5. Inspecting Transmission	5. Procedures for checking the following: • Fluid level • Leaks • Loose wiring • Loose mounts and mounting bolts • Loose cables

Presentation Outline	Steps to Cover/Key Points to Make
6. Replacing Filters	6. Need to ensure the following: ◆ Valve body is kept clean. ◆ Bottom of transmission pan is free of trash. ◆ Check valves that may be above the filter are not lost. ◆ Aeration does not occur where filter installs into valve body. ◆ Sealer does not get into valve body. ◆ Transmission pan is not bent at bolts. ◆ Transmission pan bolts are properly torqued. ◆ Pan does not leak.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could provide lessons on hydraulic pressure.

Review:

Ask students review questions such as the following:

1. What are the different types of transmission fluids, and in what vehicles are they used?
2. What can happen if you get sealer into the valve body?
3. What are some indications of bad transmission fluid?

Application:

1. Have students prepare a procedure sheet for checking transmission fluid level and condition that can be used to guide student practice in the lab.
2. As students practice inspecting an automatic transmission and replacing fluids and filters, quiz them individually on the process (e.g., ask them to explain how to change a filter and what items you must ensure during the process).

Evaluation:

√ Each student will inspect an automatic transmission and replace the fluids and filters. His/her performance will be evaluated using a copy of the performance checklist for Competency 2.2.2.

Competency 2.2.2: Service transmission; perform visual inspection; replace fluids and filters

Performance Checklist

In inspecting the transmission and replacing fluids and filters, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Performed complete visual inspection of transmission	☐	☐	☐	☐	☐
5. Performed each of the following steps in accordance with manufacturer's specifications:					
a. Drained transmission/transaxle (if possible)	☐	☐	☐	☐	☐
b. Removed oil pan	☐	☐	☐	☐	☐
c. Cleaned and inspected gasket surface	☐	☐	☐	☐	☐
d. Removed and replaced transmission filter	☐	☐	☐	☐	☐
e. Reinstalled pan and new gasket	☐	☐	☐	☐	☐
6. Installed new fluid to prescribed level	☐	☐	☐	☐	☐
7. Checked each of the following during final visual inspection:					
a. Fluid type	☐	☐	☐	☐	☐
b. Fluid level	☐	☐	☐	☐	☐
c. Condition of surfaces	☐	☐	☐	☐	☐
d. Gasket placement	☐	☐	☐	☐	☐
e. Wiring harness condition	☐	☐	☐	☐	☐
f. Tightness of fasteners/fittings	☐	☐	☐	☐	☐
8. Performed final check for leaks	☐	☐	☐	☐	☐
9. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 2: Automatic Transmission and Transaxle

Subunit 2.3: In-Vehicle Transmission and Transaxle Repair

Competency 2.3.5: Inspect, leak test, flush, and replace cooler, lines, and fittings

Competency Development Guide

Objective:

Condition:	Provided with a vehicle, basic hand tools, fluid line flushing tool, transmission fluid, and manufacturer's information; and while following all applicable safety guidelines
Behavior:	Inspect, leak-test, flush, and replace an automatic transmission cooler, lines, and fittings
Criteria:	In accordance with the criteria in the checklist for Competency 2.3.5

Introduction:

General Introductory Techniques: Share personal experiences you have had when inspecting, leak-testing, flushing, and replacing transmission coolers, lines, and fittings in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Dirt in transmission lines can ruin a transmission rebuild. This is a very expensive mistake.

2. Ask students if any of them have ever had a raspberry milkshake. A leaking transmission cooler can cause the transmission fluid to appear that way.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Transmission Cooler	2. Function Fluid heat buildup in torque converter Location Flow of transmission fluid
3. Transmission Lines	3. Design of lines and line fittings Pressure in lines
4. Checking for Leaks	4. Visual inspection Dye and black light Use of flushing tool to hold pressure in lines and cooler
5. Replacing Lines	5. Use of line wrenches (don't twist off lines) Use of line cutter, not hacksaw, if lines are cut
6. Flushing Cooler	6. Reasons for flushing cooler Operation of oil cooler and fluid line flushing tool Reverse flush Forward flush out solvent

Presentation Outline	Steps to Cover/Key Points to Make
7. Replacing Cooler	7. Automatic transmission cooler is located in radiator. If bad, radiator must be repaired or replaced. Replacement procedure for a specific vehicle

> ***Note:*** The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.
>
> For example, the applied science teacher could cover heat dissipation.

Review:

Ask students review questions such as the following:

1. When removing transmission line fittings, what do you need to be careful of?
2. What are some methods for inspecting transmission lines and coolers for leaks?
3. Since the transmission fluid is not flowing into the hot engine, why should it be cooled?

Application:

1. Have students diagram how coolant flows through a transmission cooler with a transmission oil cooler and line flushing tool attached.
2. As students practice inspecting, leak-testing, flushing, and replacing automatic transmission coolers, lines, and fittings, quiz them individually on the process (e.g., ask them to explain how to use a transmission oil cooler and line flushing tool).

Evaluation:

√ Each student will inspect, leak-test, flush, and replace an automatic transmission cooler, lines, and fittings. His/her performance will be evaluated using a copy of the performance checklist for Competency 2.3.5.

Competency 2.3.5: Inspect, leak test, flush, and replace cooler, lines, and fittings

Performance Checklist

In inspecting, leak-testing, flushing, and replacing an automatic transmission cooler, lines, and fittings, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Performed complete visual inspection for leaks	☐	☐	☐	☐	☐
5. Flushed or replaced cooler in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
6. Flushed or replaced cooler lines/fittings in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
7. Checked each of the following during final visual inspection:					
a. Fluid type	☐	☐	☐	☐	☐
b. Fluid level	☐	☐	☐	☐	☐
c. Condition of surfaces	☐	☐	☐	☐	☐
d. Gasket placement	☐	☐	☐	☐	☐
e. Wiring harness condition	☐	☐	☐	☐	☐
f. Vacuum/pressures	☐	☐	☐	☐	☐
g. Tightness of fasteners/fittings	☐	☐	☐	☐	☐
8. Performed final check for leaks	☐	☐	☐	☐	☐
9. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 2: Automatic Transmission and Transaxle

Subunit 2.4: Off-Vehicle Transmission and Transaxle Repair: Removal, Disassembly, and Reinstallation

Competency 2.4.3: Disassemble, clean, and inspect transmission/transaxle

Competency Development Guide

Objective:

Condition:	Provided with a transmission or transaxle, basic hand tools, cleaning solvent, and manufacturer's information; and while following all applicable safety guidelines
Behavior:	Disassemble, clean, and inspect an automatic transmission/transaxle
Criteria:	In accordance with the criteria in the checklist for Competency 2.4.3

Introduction:

General Introductory Techniques: Share personal experiences you have had when disassembling, cleaning, and inspecting transmissions/transaxles in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. To get a transmission correctly assembled and running in a car, it is essential that the transmission first be properly disassembled, inspected, and cleaned.

2. Nobody wants to have to do a transmission job all over again because of an improper inspection or the presence of dirt, which could cause improper shifting or no shifting of transmission.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Don't use ice pick or similar tool to remove hardened seals; the tool could go through your hand. Some people are allergic to transmission fluid.
3. Transmission Operation	3. Planetary gear sets
4. Hydraulic Parts	4. Valve body Apply piston Servos Accumulators
5. Hard parts	5. Oil pump Governor Planetary gear assemblies Multiple disc clutches One-way clutches and sprag units Brake bands Thrust washers Parking brakes

Presentation Outline	Steps to Cover/Key Points to Make
6. Disassembling Transmission	6. Refer to service manual; each type of transmission requires a different assembly procedure. Disassembly procedure for a specific type of transmission
7. Cleaning Transmission	7. Cleanliness is critical. There must be no dirt in valve body. Solvent on clutch facings may cause damage. Look for metal contamination. Do not put valve body in solvent tank. Don't gouge valve or transmission when cleaning off valve body gasket.
8. Inspecting Transmission	8. Each manufacturer has inspection procedures common to individual transmissions. One manufacturer's procedures for inspecting the following: ◆ Planetary gear sets ◆ Friction surfaces ◆ Steel driveplates ◆ Clutch springs ◆ Thrust washers ◆ Oil pump ◆ One-way roller clutches and sprags ◆ Apply pistons and accumulators ◆ Case ◆ Governor

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could work with students on measuring.

Review:

Ask students review questions such as the following:

1. What are some of the hydraulic parts of a transmission?
2. What are some of the hard parts of a transmission?

Application:

1. Provide students with a diagram applicable to a specific manufacturer's transmission, and have them identify parts and powerflow though transmission in all gears.
2. Provide students with a disassembled transmission of the type to be disassembled, and have them identify all parts and the gears in which the parts are applied.

Evaluation:

√ Each student will disassemble, clean, and inspect an automatic transmission/transaxle. His/her performance will be evaluated using a copy of the performance checklist for Competency 2.4.3.

Competency 2.4.3: Disassemble, clean, and inspect transmission/transaxle

Performance Checklist

In disassembling, cleaning, and inspecting an automatic transmission/transaxle, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Disassembled transmission/transaxle assembly in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
5. Cleaned assembly components so that they were completely free of dirt and contamination	☐	☐	☐	☐	☐
6. Inspected each assembly component in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
7. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name_______________________________________**Date**_____________

Unit 2: Automatic Transmission and Transaxle

Subunit 2.4: Off-Vehicle Transmission and Transaxle Repair: Removal, Disassembly, and Reinstallation

Competency 2.4.4: Assemble transmission/transaxle

Competency Development Guide

Objective:

Condition:	Provided with a disassembled transmission/transaxle and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Assemble an automatic transmission/transaxle
Criteria:	In accordance with the criteria in the checklist for Competency 2.4.4

Introduction:

General Introductory Techniques: Share personal experiences you have had when assembling automatic transmissions/transaxles in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Now that you've taken a transmission apart, let's focus on putting the transmission back together again.
2. Ask students: How many of you think you would be willing to drive home on a transmission you had put together?

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Allergies related to automatic transmission fluid
3. Preparing for Assembly	3. Soak clutches in automatic transmission fluid (or let assembled transmission warm up for 5 minutes before shifting). Properly lubricate seals and thrust washers. Parts of disassembled transmission (see 2.4.3) Maintain cleanliness around valve body.
4. Assembling Transmission	4. Refer to service manual; each type of transmission requires a different assembly procedure. Assembly procedure for a specific type of transmission Ensure that thrust washers are installed in correct direction and all are in correct location. Assembled transmission should have proper transmission main shaft endplay.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could work with students on obtaining measurements using micrometers.

Review:

Ask students review questions such as the following:

1. What are the parts that make up your disassembled transmission?
2. What is the importance of endplay, and what could it mean if the endplay on your assembled transmission is too little or too great?
3. What types of lubrication are used on seals during assembly? on friction plates?

Application:

1. Prior to assembly, have students lay out the parts in the order in which they will go into the transmission.
2. Have students identify, by name, all the disassembled parts and match them up with a diagram from the service manual.

Evaluation:

√ Each student will assemble an automatic transmission/transaxle. His/her performance will be evaluated using a copy of the performance checklist for Competency 2.4.4.

Competency 2.4.4: Assemble transmission/transaxle

Performance Checklist

In assembling an automatic transmission/transaxle, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Assembled transmission/transaxle in accordance with manufacturer's instructions	☐	☐	☐	☐	☐
5. Checked each of the following during final visual inspection:					
a. Fluid type	☐	☐	☐	☐	☐
b. Fluid level	☐	☐	☐	☐	☐
c. Condition of surfaces	☐	☐	☐	☐	☐
d. Gasket placement	☐	☐	☐	☐	☐
e. Wiring harness condition	☐	☐	☐	☐	☐
f. Vacuum/pressures	☐	☐	☐	☐	☐
g. Tightness of fasteners/fittings	☐	☐	☐	☐	☐
6. Performed final check for leaks	☐	☐	☐	☐	☐
7. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name______________________________________**Date**______________

Unit 2: Automatic Transmission and Transaxle

Subunit 2.5: Off-Vehicle Transmission and Transaxle Repair: Oil Pump and Converter

Competency 2.5.4: Check torque converter and transmission cooling system for contamination

Competency Development Guide

Objective:

Condition:	Provided with a torque converter, transmission cooling system, and manufacturer's information; and while following all applicable safety guidelines
Behavior:	Check the torque converter and transmission cooling system for contamination
Criteria:	In accordance with the criteria in the checklist for Competency 2.5.4

Introduction:

General Introductory Techniques: Share personal experiences you have had when checking torque converters and transmission cooling systems for contamination in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Explain what a small amount of dirt in the torque converter or transmission cooling system will do to a newly rebuilt transmission.

2. Show students a burnt clutch.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Fluid Coupling	2. Theory and operation
3. Parts	3. Pump Turbine Stator Torque converter clutch (TCC)
4. Visual Torque Converter Inspection	4. Procedure for checking each of the following: • Stator (locked or goes both ways) • Oil pump drive and seal • Turbine shaft bushing • Starter teeth • Bolt holes
5. Contamination	5. Types of contamination: • Burnt fluid • Discoloration • Friction materials • Metals

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could discuss oil life with temperature and friction.

Review:

Ask students review questions such as the following:

1. What are the operating principles of a torque converter?
2. What are the main parts of a torque converter?
3. What does TCC stand for, and how does a TCC work?

Application:

1. Divide the class into groups, and have each group list and describe the types of torque converter failure complaints they will typically get from customers.
2. As students practice checking a torque converter and transmission cooling system for contamination, quiz them individually on the process (e.g., ask them to list some of the items you should inspect on the torque converter).

Evaluation:

√ Each student will check a torque converter and transmission cooling system for contamination. (It may be advantageous to lay several torque converters on a bench for student inspection.) His/her performance will be evaluated using a copy of the performance checklist for Competency 2.5.4.

Competency 2.5.4: Check torque converter and transmission cooling system for contamination

Performance Checklist

In checking a torque converter and transmission cooling system for contamination, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Visually inspected torque converter in accordance with prescribed procedure	☐	☐	☐	☐	☐
5. Visually inspected transmission cooling system in accordance with prescribed procedure	☐	☐	☐	☐	☐
6. Located all instances of contamination	☐	☐	☐	☐	☐
7. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name_______________________________________**Date**_____________

Competency 2.7.2: Measure clutch pack clearance; adjust as needed

Competency Development Guide

Objective:

Condition:	Provided with a clutch pack, spring compressor, feeler gauges, and manufacturer's information; and while following all applicable safety guidelines
Behavior:	Measure clutch pack clearance, and adjust it as needed
Criteria:	In accordance with the criteria in the checklist for Competency 2.7.2

Introduction:

General Introductory Techniques: Share personal experiences you have had when measuring and adjusting clutch pack clearance in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Nobody wants to have to take apart a transmission because it won't shift into or out of a gear.
2. Present a clutch pack for students to view.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Cautions related to— • presence of asbestos in clutch friction materials • getting hit by springs or clips, especially in the eye
3. Clutches and Clutch Assembly	3. Materials and construction Application (how fluid pressure is applied and removed) Checking for free check balls if necessary
4. Clutch Pack	4. Problems with insufficient clearance Problems with excessive clearance
5. Disassembling Clutch Pack	5. Disassembly procedure for a specific clutch pack Use of spring compressor Soaking replacement clutches in transmission fluid

Presentation Outline	Steps to Cover/Key Points to Make
6. Inspecting Clutch Pack	6. Need to ensure the following: ◆ Apply piston is not cracked, and seals are not damaged. ◆ Pressure plate is correctly installed. ◆ Steel plates are not scored, scuffed, or severely spotted. ◆ Clutch release springs are not warped. ◆ Drive plates are not pitted, glazed, cracked, worn, charred, or contaminated. ◆ Number of clutches is correct. ◆ Clearance is correct.
7. Reassembling Clutch Pack	7. Reassembly procedure for a specific clutch pack Importance of using proper lube on seals when reassembling

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could cover micrometer usage.

Review:

Ask students review questions such as the following:

1. What symptoms will appear if a clutch pack is incorrectly adjusted?
2. What safety concerns should you have when assembling or disassembling a clutch pack to obtain correct clearance?

Application:

1. Have students prepare a procedure sheet listing the steps that should be followed if the clutch clearance is incorrect.
2. Have students measure various clutch discs using a micrometer.

Evaluation:

√ Each student will measure clutch pack clearance and adjust it as needed. His/her performance will be evaluated using a copy of the performance checklist for Competency 2.7.2.

Competency 2.7.2: Measure clutch pack clearance; adjust as needed

Performance Checklist

In measuring clutch pack clearance and adjusting it as needed, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Disassembled clutch pack in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
5. Inspected clutch pack thoroughly for damage	☐	☐	☐	☐	☐
6. Measured clutch pack clearance accurately	☐	☐	☐	☐	☐
7. Adjusted clutch pack clearance as needed	☐	☐	☐	☐	☐
8. Reassembled clutch pack in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
9. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**_____________

Competency 2.7.3: Air test operation of clutch and servo assemblies

Competency Development Guide

Objective:

Condition:	Provided with an assembled transmission, air pressure, service manuals, and pressure test plate if required; and while following all applicable safety guidelines
Behavior:	Air-test the operation of transmission clutch and servo assemblies
Criteria:	In accordance with the criteria in the checklist for Competency 2.7.3

Introduction:

General Introductory Techniques: Share personal experiences you have had when air-testing clutch and servo assembly operation in the auto tech shop. Show videos that demonstrate the steps in this process.

Competency-Specific Information:

1. It's important not to put a transmission into a vehicle without checking it first. Air-testing provides a way of inspecting the seals of a transmission to determine that they are not leaking excessively.
2. Display a mockup of an automatic transmission with air hose.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Problems with excess air pressure at air nozzle
3. Theory of Air Checking	3. Putting air in different circuits of the transmission fluid lines can operate different clutches, accumulators, and bands.
4. Valve Body	4. Proper care of valve body when removing or installing ***Key points:*** • Don't lose check balls (note location and size). • Use proper torque.
5. Pressure Test Plates	5. Used on newer model transmissions Proper torque of plate
6. Air Check Procedure	6. Need to follow manufacturer or Automatic Transmission Rebuilders Association (ATRA) specifications Procedure for removing and installing valve body and/or pressure testing plate Location of check ports

> ***Note:*** The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.
>
> For example, the applied science teacher could provide lessons on hydraulic pressure.

Review:

Ask students review questions such as the following:

1. What concerns should be noted when you are removing and installing the valve body?
2. What are the advantages of air-checking clutch and servo assemblies?
3. What are disadvantages of air-checking clutch and servo assemblies?

Application:

1. Give students a specific model of automatic transmission, and have them diagram the circuits that can be checked.
2. As students practice air-testing clutch and servo assemblies, quiz them individually on the process (e.g., ask them to explain specific steps in the procedure).

Evaluation:

√ Each student will air-test the operation of transmission clutch and servo assemblies. His/her performance will be evaluated using a copy of the performance checklist for Competency 2.7.3.

Competency 2.7.3: Air test operation of clutch and servo assemblies

Performance Checklist

In air-testing the operation of transmission clutch and servo assemblies, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Showed proper care of valve body when removing or installing it	☐	☐	☐	☐	☐
5. Air-tested clutch assemblies in accordance with manufacturer's or ATRA procedure	☐	☐	☐	☐	☐
6. Air-tested servo assemblies in accordance with manufacturer's or ATRA procedure	☐	☐	☐	☐	☐
7. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name_______________________________________**Date**______________

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and Axles"
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Unit 3: Manual Drive Train and Axles

Subunit 3.1: Clutch Diagnosis and Repair

Competency 3.1.1: Diagnose clutch noise, binding, slippage, pulsation, and chatter problems; determine needed repairs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Diagnose clutch noise, binding, slippage, pulsation, and chatter problems; and determine needed repairs
Criteria:	In accordance with the criteria in the checklist for Competency 3.1.1

Introduction:

General Introductory Techniques: Share personal experiences you have had when diagnosing clutch problems in the auto tech shop. Show videos that demonstrate the steps in this process.

Competency-Specific Information:

1. Basic clutch operation as a system is similar for most cars and light trucks. Its function is to engage or disengage transmission to engine.

2. The repair of clutch problems is critical since they prevent the smooth transfer of power from the engine to the transmission.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Be aware of moving parts in the engine compartment. Exhaust removal system ***must*** be used when engine is running inside the auto shop.
3. Clutch and Component Parts	3. Parts: ◆ Clutch disc ◆ Pressure plate ◆ Flywheel ◆ Pilot bearing ◆ Release bearing ◆ Release arm Location of each Function of each Samples of components Examples of worn components
4. Hydraulic Clutch vs. Mechanical Clutch Linkage	4. Hydraulic clutch uses master/slave cylinder to control clutch. Mechanical clutch linkage uses a cable between pedal and transmission.

Presentation Outline	Steps to Cover/Key Points to Make
5. Clutch System Operation	5. Similar operation for most cars and light trucks How clutch systems typically operate Problems that can affect clutch operation: ◆ Worn components ◆ Warped flywheel ◆ Loose springs
6. Diagnosis Tools	6. Feedback from customer interview Listening Feeling the pedal Visual inspection
7. Determining Needed Repairs	7. Using diagnostic information gathered, refer to service manuals to identify needed repairs.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher may help students with determining the area of the clutch surface. The applied science teacher could cover spring tension.

Review:

Ask students review questions such as the following:

1. What could cause clutch noise? binding? slippage? pulsation? chatter?
2. What are some common symptoms of a worn clutch?

Application:

1. Have students identify components on a teacher-prepared diagram of a clutch system.
2. As students practice examination of the clutch system, have them explain to you the operation of the components and where/how to locate wear on components.
3. Set up a display of worn components (worn clutch disc, warped flywheel, broken pressure plate fingers, noisy release bearing), and have students prepare a table, naming each condition and listing the problems each might present.
4. As students practice diagnosing clutch problems and determining needed repairs, quiz them individually on the process (e.g., ask them to explain a specific component's function).

Evaluation:

√ Each student will diagnose clutch noise, binding, slippage, pulsation, and chatter problems and determine needed repairs. His/her performance will be evaluated using a copy of the performance checklist for Competency 3.1.1.

Competency 3.1.1: Diagnose clutch noise, binding, slippage, pulsation, and chatter problems; determine needed repairs

Performance Checklist

In diagnosing clutch problems and determining needed repairs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Secured needed information through customer interview	☐	☐	☐	☐	☐
5. Performed complete visual inspection of clutch components	☐	☐	☐	☐	☐
6. Tested clutch pedal for proper operation according to prescribed procedure	☐	☐	☐	☐	☐
7. Checked/adjusted clutch pedal in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
8. Determined needed repairs	☐	☐	☐	☐	☐
9. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 3: Manual Drive Train and Axles

Subunit 3.1: Clutch Diagnosis and Repair

Competency 3.1.2: Inspect, adjust or replace clutch pedal linkage, cables, automatic adjuster mechanisms, brackets, bushings, pivots, and springs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Inspect and adjust or replace clutch pedal linkage, cables, automatic adjuster mechanisms, brackets, bushings, pivots, and springs
Criteria:	In accordance with the criteria in the checklist for Competency 3.1.2

Introduction:

General Introductory Techniques: Share personal experiences you have had when inspecting and adjusting or replacing clutch components in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Proper clutch repairs are very important to customer satisfaction. They ensure that the clutch will operate smoothly and deliver engine torque to the transmission.

2. Show students the linkage of a clutch, and explain pivot points that can wear.

References:

Technical service bulletins (TSBs). (See listing of standard textbooks for the field, (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Be aware of moving parts in the engine compartment. Exhaust removal system ***must*** be used when engine is running inside the auto shop.
3. How Clutch Is Controlled	3. A cable and levers are used to multiply the force needed to engage or disengage the clutch.
4. Clutch Components	4. Components: • Clutch pedal linkage • Cables • Automatic adjuster mechanisms • Brackets • Bushings • Pivots • Springs Location of each Function of each Samples of components Examples of worn components

Presentation Outline	Steps to Cover/Key Points to Make
5. Clutch Linkage Operation	5. Clutch linkage operation for a specific vehicle How worn components prohibit proper functioning
6. Determining Needed Repairs	6. Using diagnostic information gathered, refer to service manuals to identify needed repairs.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics or science teacher may help students with multiplication of force with levers.

Review:

Ask students review questions such as the following:

1. How does the clutch shift linkage work?
2. Why are levers used to multiply (increase) the force?

Application:

1. Give students written case studies describing customers' explanations of vehicle clutch problems. Have each student list step by step exactly how he or she would proceed in order to interpret and verify each customer's concern(s).
2. Give students a teacher-prepared diagram of a clutch system, and have them identify the specific components.
3. Set up a display of worn components (worn linkage points, broken mounts, broken springs), and have students prepare a table, naming each condition and listing the problems each might present.

Evaluation:

√ Each student will inspect and adjust or replace clutch pedal linkage, cables, automatic adjuster mechanisms, brackets, bushings, pivots, and springs. His/her performance will be evaluated using a copy of the performance checklist for Competency 3.1.2.

Competency 3.1.2: Inspect, adjust or replace clutch pedal linkage, cables, automatic adjuster mechanisms, brackets, bushings, pivots, and springs

Performance Checklist

In inspecting and adjusting or replacing clutch components, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Performed complete visual inspection of clutch linkages	☐	☐	☐	☐	☐
5. Tested clutch components for proper operation according to prescribed procedure	☐	☐	☐	☐	☐
6. Determined needed repairs	☐	☐	☐	☐	☐
7. Adjusted or replaced necessary clutch components in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
8. Checked the following during final visual inspection:					
a. Fluid level	☐	☐	☐	☐	☐
b. Tightness of fasteners/fittings	☐	☐	☐	☐	☐
9. Performed final check for leaks	☐	☐	☐	☐	☐
10. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 3: Manual Drive Train and Axles

Subunit 3.1: Clutch Diagnosis and Repair

Competency 3.1.3: Inspect, adjust, repair or replace hydraulic clutch slave and master cylinders, lines, and hoses

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Inspect, adjust, and repair or replace hydraulic clutch slave and master cylinders, lines, and hoses
Criteria:	In accordance with the criteria in the checklist for Competency 3.1.3

Introduction:

General Introductory Techniques: Share personal experiences you have had when inspecting, adjusting, and repairing or replacing hydraulic clutch slave and master cylinders, lines, and hoses in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Proper operation of the clutch hydraulic system is important to its engagement and safety.

2. Without proper operation, engagement will be rough or impossible.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Be aware of moving parts in the engine compartment. Exhaust removal system ***must*** be used when engine is running inside the auto shop.
3. Hydraulic Clutch Components	3. Components: ◆ Clutch master cylinder ◆ Slave cylinder ◆ Lines ◆ Hoses Comparison to cable clutch (fewer parts) Location of each Function of each Samples of components Examples of worn components
4. Hydraulic Clutch System Operation	4. Hydraulic clutch system operation for a specific vehicle Problems with worn parts (e.g., fluid leaks)
5. Bleeding Procedures	5. Similarity to procedure for brake system Bleeding procedure for a specific vehicle

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher may assist students with Pascal's law (F = PA) and finding area of bores.

Reviews:

Ask students review questions such as the following:

1. How does the hydraulic system differ from the cable clutch system?
2. What are the advantages of the hydraulic clutch system?

Application:

1. Give students a case study describing a specific problem a customer is having with his or her vehicle (e.g., clutch does not engage properly), and ask them to identify the possible cause(s) of this problem?
2. As students practice adjusting a hydraulic clutch, quiz them individually on the process (e.g., ask them to explain to you its operation).
3. Give students a teacher-prepared diagram of a hydraulic clutch system, and have them identify specific components.

Evaluation:

√ Each student will inspect, adjust, and repair or replace hydraulic clutch slave and master cylinders, lines, and hoses. His/her performance will be evaluated using a copy of the performance checklist for Competency 3.1.3.

Competency 3.1.3: Inspect, adjust, repair or replace hydraulic clutch slave and master cylinders, lines, and hoses

Performance Checklist

In inspecting, adjusting, and repairing or replacing hydraulic clutch slave and master cylinders, lines, and hoses, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Performed complete visual inspection of hydraulic clutch slave system	☐	☐	☐	☐	☐
5. Determined specific repairs or service needed	☐	☐	☐	☐	☐
6. Adjusted, repaired, or replaced necessary components in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
7. Bled clutch hydraulic system in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
8. Checked each of the following during final visual inspection:					
a. Fluid type	☐	☐	☐	☐	☐
b. Fluid level	☐	☐	☐	☐	☐
c. Condition of fluid	☐	☐	☐	☐	☐
d. Gasket placement	☐	☐	☐	☐	☐
e. Tightness of fasteners/fittings	☐	☐	☐	☐	☐
9. Performed final check for leaks	☐	☐	☐	☐	☐
10. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 3: Manual Drive Train and Axles

Subunit 3.2/3.3: Transmission/Transaxle Diagnosis and Repair

Competencies 3.2.1/3.3.1: Diagnose transmission/transaxle noise, hard shifting, jumping out of gear, and fluid leakage problems; determine needed repairs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Diagnose transmission/transaxle noise, hard shifting, jumping out of gear, and fluid leakage problems; and determine needed repairs
Criteria:	In accordance with the criteria in the checklist for Competencies 3.2.1/3.3.1

Introduction:

General Introductory Techniques: Share personal experiences you have had when diagnosing transmission/transaxle noise, hard shifting, jumping out of gear, and fluid leakage problems in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Customers fully expect that their vehicles will stay in the gear they have selected and that it will be somewhat easy to shift into that gear. They also do not want fluids to leak on the driveways or garage floors where they park.

2. Thus, it is important to check the transmission for noises, shifting problems, and leaks so you can identify any problems and determine how they can be remedied.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Be aware of moving parts in the engine compartment. Exhaust removal system ***must*** be used when engine is running inside the auto shop.
3. Review: Clutch Types & Operation	3. Operation of hydraulic and cable clutch mechanism Diagnosis of noise, slippage, pulsation
4. Clutch Inspection Process	4. Procedures for checking the following: • Shift and clutch linkages • Fluid leaks • Fastener Locating specific information using TSBs Examples of conditions (inspection points) to look for: • Leaking seals • Misadjusted linkages • Worn cables • Leaking hydraulic systems

Presentation Outline	Steps to Cover/Key Points to Make
5. Transaxle Service and Adjustment	5. Change fluid, adjust linkages, and replace seal. Eliminate all external-to-transmission causes. Then the problem may be in the transmission, shift forks, synchronizers, bearings, or detents.
6. Determining Needed Repairs	6. Using diagnostic information gathered, refer to service manuals to identify needed repairs.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher may assist students with multiplication of force with levers.

Review:

Ask students review questions such as the following:

1. What kinds of problems might you expect to find when checking the transmission or transaxle system of a vehicle?
2. Why is it important to use the correct type of fluid in the transmission?

Application:

1. Give students a case study describing a specific transmission/transaxle problem a customer is having with his or her vehicle, and have them identify the possible cause(s) of this problem.
2. Give students teacher-prepared diagrams of transmission and transaxle systems, and have them identify the specific components of each.
3. Set up a display of worn components (worn clutch discs, worn axle shaft bearing), and have students prepare a table, naming each condition and listing the problems each might present.

Evaluation:

√ Each student will diagnose transmission/transaxle noise, hard shifting, jumping out of gear, and fluid leakage problems and determine needed repairs. His/her performance will be evaluated using a copy of the performance checklist for Competencies 3.2.1/3.3.1.

Competencies 3.2.1/3.3.1: Diagnose transmission/transaxle noise, hard shifting, jumping out of gear, and fluid leakage problems; determine needed repairs

Performance Checklist

In diagnosing transmission/transaxle problems and determining needed repairs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Secured needed information through customer interview	☐	☐	☐	☐	☐
4. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
5. Performed complete visual inspection of transmission/ transaxle	☐	☐	☐	☐	☐
6. Checked operation of shift linkages	☐	☐	☐	☐	☐
7. Checked fluid level, including visual check for leaks	☐	☐	☐	☐	☐
8. Determined needed repairs	☐	☐	☐	☐	☐
9. Adjusted or serviced transmission or transaxle in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
10. Checked each of the following during final visual inspection:					
a. Fluid type	☐	☐	☐	☐	☐
b. Fluid level	☐	☐	☐	☐	☐
c. Condition of fluid	☐	☐	☐	☐	☐
d. Gasket placement	☐	☐	☐	☐	☐
e. Wiring harness condition	☐	☐	☐	☐	☐
f. Tightness of fasteners/fittings	☐	☐	☐	☐	☐
11. Performed final check for leaks	☐	☐	☐	☐	☐
12. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

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Unit 4: Suspension and Steering

Subunit 4.1: Steering Systems Diagnosis and Repair

Competency 4.1.1: Disable supplemental restraint systems (SRS)

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Disable a supplemental restraint system (SRS)
Criteria:	In accordance with the criteria in the checklist for Competency 4.1.1

Introduction:

General Introductory Techniques: Share personal experiences you have had when disabling/deploying air bag systems in the auto tech shop. Show videos that demonstrate air bag disabling/deployment procedures and some of the problems a technician can encounter.

Competency-Specific Information:

1. Ask students if they are aware of recent stories in the media about the force and impact an air bag has when it is deployed. Discuss airbag on/off switches that, as of January 1998, may be installed by dealers and certified mechanics with NHTSA approval.

2. Share recent articles printed in trade journals (or available through the Internet) about air bag concerns.

3. Discuss important features of air bag safety.

References:

Technical service bulletins (TSBs) and relevant publications or Website information available from the National Highway Traffic Safety Administration (NHTSA), Department of Transportation (DOT); National Transportation Safety Board (NTSB); and Automotive Service Excellence (ASE). See particularly www.nhtsa.dot.gov/airbags. (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Applicable Safe Practices	2. Potential speed and force encountered when air bag is deployed Labeling or color-coding of appropriate connections by manufacturers
3. Reasons for Disabling Air Bags	3. To work on air bag system To work within steering column or on passenger side of dash area
4. Air Bag System Components	4. Sensors (arming, discriminating) Power supply (backup power, how long) Control modes (deployment conditions) ***Note:*** Refer to service manuals for specific information.
5. Air Bag System Operation (No Fault)	5. Operation of air bag system for a given manufacturer ***Note:*** Operation will vary from manufacturer to manufacturer.

Presentation Outline	Steps to Cover/Key Points to Make
6. Disabling Procedure	6. Disabling procedure for a specific vehicle, including— • Locate and remove fuses. • Locate and disconnect arming module connections. ***Note:*** For student safety, air bags should be disabled in the auto technician learning laboratory prior to the deployment procedure (and should remain ***permanently*** disabled).

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher may assist with demonstrating the force exerted when an airbag is deployed.

Review:

Ask students review questions such as the following:

1. During which types of vehicle repairs would it be important to disable the air bag system?
2. Will disconnecting the vehicle from the battery ensure that the air bag system will remain inoperable? Explain why or why not.
3. Why is the systems' energy reserve important when servicing or disabling air bags?

Application:

1. Give students a teacher-prepared diagram of an air bag system, and have them label the components.
2. As students practice disabling a supplemental restrain system, quiz them individually on the process (e.g., ask them to summarize the disabling procedure).

Evaluation:

√ Each student will disable a supplemental restraint system (SRS). His/her performance will be evaluated using a copy of the performance checklist for Competency 4.1.1.

Competency 4.1.1: Disable supplemental restraint systems (SRS)

Performance Checklist

In disabling a supplemental restraint system, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Secured needed information through customer interview ...	☐	☐	☐	☐	☐
4. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
5. Disabled supplemental restraint systems (SRS) in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
6. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name_______________________________________**Date**_____________

Unit 4: Suspension and Steering

Subunit 4.1: Steering Systems Diagnosis and Repair

Competency 4.1.11: Inspect manual and power steering fluid levels and condition

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Inspect manual and power steering fluid levels and condition
Criteria:	In accordance with the criteria in the checklist for Competency 4.1.11

Introduction:

General Introductory Techniques: Share personal experiences you have had when inspecting manual and power steering fluid levels and condition in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Discuss importance of the fluid level and condition to operation of vehicle and how this relates to vehicle performance.

2. Ask students what problem might occur if fluid level is not maintained at required level (e.g., steering noise, steering difficulty, damage to steering components).

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. System Components	2. Manual steering gear Power steering gear, pump Rack and pinion ***Note:*** Refer to service manuals for specific information.
3. Fluids	3. Types of fluids used: • Gear oil • Power steering fluid How to determine fluid condition Location of lubrication checkpoints (dip stick, access bolt, etc.)
4. Fluid Checks	4. Procedure for checking for proper fluid level Causes of fluid loss (e.g., leaking hoses, fittings, seals) Procedure for checking fluid condition: • Check for metal shavings. • Check for grey (blackish) appearance of power steering fluid (normally clear). Causes of contamination: • Component wear (pump, rack/pinion sleeves) • Improper fluid use

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher may address the properties of fluid products and their actions. The applied mathematics teacher may address reading and interpreting gauges and measurements.

Review:

Ask students review questions such as the following:

1. What type of fluid is normally used in a manual gear box?
2. How can you determine whether a fluid is contaminated?

Application:

1. Give students a teacher-prepared diagram, and have them label the lubrication checkpoints found on specific components.
2. As students practice inspecting steering fluid levels and conditions, quiz them individually on the process (e.g., ask them to identify lubrication checkpoints, to indicate specific components affected by lubrication, and/or to describe the fluid level and condition).

Evaluation:

√ Each student will inspect manual and power steering fluid levels and condition. His/her performance will be evaluated using a copy of the performance checklist for Competency 4.1.11.

Competency 4.1.11: Inspect manual and power steering fluid levels and condition

Performance Checklist

In inspecting manual and power steering fluid levels and condition, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Performed complete visual inspection	☐	☐	☐	☐	☐
5. Located proper checkpoint	☐	☐	☐	☐	☐
6. Accurately determined power steering fluid level	☐	☐	☐	☐	☐
7. Accurately determined power steering fluid condition	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 4: Suspension and Steering

Subunit 4.1: Steering Systems Diagnosis and Repair

Competency 4.1.14: Inspect, replace, and adjust power steering pump belt

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Inspect, replace, and adjust a power steering pump belt
Criteria:	In accordance with the criteria in the checklist for Competency 4.1.14

Introduction:

General Introductory Techniques: Share personal experiences you have had when inspecting, replacing, and adjusting power steering belts in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Cite problems that occur when a vehicle has a faulty power steering belt.
2. Show a worn power steering belt, and explain how the wear affects the vehicle's steering and operation.
3. Ask students what type of customer complaint might indicate the need to replace the power steering belt.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Rotating fan blades can be dangerous. A worn belt can break when near a running engine.
3. Types of Wear Patterns on Power Steering Belts	3. Specific wear that indicates that belt replacement is necessary: ◆ Cracks ◆ Dry rot ◆ Fraying ◆ Glazing ◆ Oil (fluid)-soaked
4. Selecting Correct Type of Belt	4. V belt—v-shaped; drives only one accessory Serpentine belt—multi-ribbed; may drive all accessories ***Note:*** Refer to manufacturer's specifications.
5. Determining Tensioner Type	5. Manual tensioner—an accessory (power steering pump); moves to release tension on the belt. Automatic tensioner—spring-loaded pulley; applies constant tension on belt through load and RPM changes.

Presentation Outline	Steps to Cover/Key Points to Make
6. Releasing Belt Tension	6. If using an auto tensioner, release slowly to avoid damage to internal spring.
7. Removing/Inspecting Belt	7. Check for signs of wear. Determine needed repairs.
8. Inspecting Drive Pulleys	8. Check for the following: ◆ Pulley alignment ◆ Sharp edges ◆ Cracks ◆ Signs of damage ◆ Bent shafts Determine needed repairs.
9. Installing Belt on Pulleys	9. Ensure correct installation on pulleys (refer to manufacturer's specifications).
10. Manual Tensioning	10. Apply tension to accessory that tightens the belt. Set tension with tension gauge in accordance with manufacturer's specifications. Tighten accessory fasteners in accordance with manufacturer's specifications.
11. Auto Tensioner	11. Rotate tensioner pulley to put belt on. Release tensioner slowly.
12. Checking Belt Seating	12. Belt should fully seat in pulley grooves.
13. Ensuring Proper Operation	13. Start engine. Check whether belt is operating properly.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher may demonstrate reaction to belt tension and properties of materials used to make belts.

Review:

Ask students review questions such as the following:

1. What problem may occur if a power steering belt is overtightened?

2. What would you recommend to a customer if you found a very minor indication that a belt was cracking?

Application:

1. Give students a teacher-prepared diagram of a power steering system, and have them indicate the belt placement and label the components that allow adjustment.

2. As students practice inspecting, replacing and adjusting power steering pump belts, quiz them individually on the process (e.g., ask them to list the steps in replacing or adjusting a belt).

Evaluation:

√ Each student will inspect, replace, and adjust a power steering pump belt. His/her performance will be evaluated using a copy of the performance checklist for Competency 4.1.14.

Competency 4.1.14: Inspect, replace, and adjust power steering pump belt

Performance Checklist

In inspecting, replacing, and adjusting a power steering belt, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Performed complete visual inspection of power steering belt	☐	☐	☐	☐	☐
5. Replaced power steering belt in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
6. Adjusted power steering belt in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
7. Performed final visual inspection	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 4: Suspension and Steering

Subunit 4.2: Suspension Systems Diagnosis and Repair: Front Suspensions

Competency 4.2.11: Remove, inspect, and replace MacPherson strut cartridge or assembly, strut coil spring, insulators, and upper strut bearing mount

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Remove, inspect, and replace a MacPherson strut cartridge or assembly, strut coil spring, insulators, and upper strut bearing mount
Criteria:	In accordance with the criteria in the checklist for Competency 4.2.11

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when removing, inspecting, and replacing a MacPherson strut cartridge or assembly, strut coil spring, insulators, and upper strut bearing mount. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Explain the symptoms of faulty suspension components (e.g., MacPherson struts and/or coil springs).

2. Show students a strut assembly, and explain the types of problems that might occur with a worn or broken strut assembly.

3. Ask students whether they think alignment would be affected following repair or replacement of strut assembly?

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Danger associated with compressed coil springs; pressure and force of coiled spring
3. Types of Suspension Problems	3. Spring sag Poor steering of vehicle Poor ride Loss of control Excessive vehicle bounce
4. Strut Assembly Functions/Operation	4. Functions: • Provides compact design to absorb road shock • Steering functions Operation of strut assembly for a given manufacturer (refer to manufacturer's manual specific to vehicle for diagrams)

Presentation Outline	Steps to Cover/Key Points to Make
5. Disassembling Strut Assembly Unit	5. General procedure: • Remove unit from vehicle. • Secure coil spring with spring compressor. • Remove retaining nut. • Release tension on spring slowly. • Remove coil spring, insulators, and upper mounts from strut body. Importance of— • using appropriate spring compressor • safety protection
6. Replacing/Repairing Strut Assembly	6. Types of units: • Sealed unit—strut is sealed, and shock unit is not replaceable. • Serviceable unit—top of strut unit can be opened to remove shock unit. Most will be wet design (oil in strut to lube inner wall of strut body). Procedure for replacing strut assembly for a specific vehicle Procedure for repairing strut assembly for a specific vehicle ***Note:*** Procedures will vary from manufacturer to manufacturer.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher may demonstrate tension of coiled spring.

Review:

Ask students review questions such as the following:

1. What symptoms indicate that a vehicle's MacPherson strut assembly needs to be repaired or replaced?
2. How can you determine whether the strut cartridge has lost oil during strut assembly repair or replacement?
3. What key safety concerns are associated with strut disassembly?

Application:

1. Give students a teacher-prepared diagram of a MacPherson strut assembly, and have them label the components.
2. Have students set up the special tools required for strut disassembly.
3. As students practice removing, inspecting, and replacing a MacPherson strut cartridge or assembly, strut coil spring, insulators, and upper strut bearing mount, quiz them individually on the process (e.g., ask them to summarize the steps in the strut disassembly/reassembly procedure).

Evaluation:

√ Each student will remove, inspect, and replace a MacPherson strut cartridge or assembly, strut coil spring, insulators, and upper strut bearing mount. His/her performance will be evaluated using a copy of the performance checklist for Competency 4.2.11.

Competency 4.2.11: Remove, inspect, and replace MacPherson strut cartridge or assembly, strut coil spring, insulators, and upper strut bearing mount

Performance Checklist

In removing, inspecting, and replacing a MacPherson strut cartridge or assembly, strut coil spring, insulators, and upper strut bearing mount, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Removed strut assembly from vehicle in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
5. Performed complete visual inspection of assembly	☐	☐	☐	☐	☐
6. Disassembled strut assembly in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
7. Inspected strut assembly components for needed replacement	☐	☐	☐	☐	☐
8. Installed strut cartridge and assembly in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
9. Assembled strut components in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
10. Reinstalled strut assembly in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
11. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 4: Suspension and Steering/Brakes

Subunits 4.4/5.5: Suspension Systems Diagnosis and Repair: Miscellaneous Service/ Miscellaneous (Wheel Bearings, Parking Brakes, Electrical, Etc.) Diagnosis and Repair

Competency 4.4.2: Remove, inspect, and service or replace front and rear wheel bearings

Competency 5.5.2: Remove, clean, inspect, repack, and reinstall wheel bearings and replace seals; reinstall hub and adjust wheel bearings

Competency 5.5.7: Replace wheel bearing and race

Competency Development Guide

Objective:

Condition: Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines

Behavior: Remove, clean, inspect, and service or replace front and rear wheel bearings (serviceable tapered roller bearings) and races; replace seals; reinstall the hub; and adjust wheel bearings

Criteria: In accordance with the criteria in the checklist for Competencies 4.4.2/5.5.2/ 5.5.7

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when removing, cleaning, inspecting, and servicing or replacing front and rear wheel bearings and races; replacing seals; reinstalling hubs; and adjusting wheel bearings. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Wheel bearing service is critical to any brake or suspension system repair.
2. Discuss why proper adjustment is necessary for good bearing performance and long life.
3. Explain the need for proper lubrication and adjustment of the front and rear wheel bearings and how this relates to proper vehicle operation.
4. Explain symptoms the customer might describe when a wheel bearing is not operating properly.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Safety concerns associated with improper lubrication or adjustment
3. Maintenance Schedule	3. Bearings should typically be serviced every 30,000 miles (refer to manufacturer's maintenance schedule for specific vehicle).
4. Use of Tapered Roller Bearings	4. Bearings are used in pairs, with tapers facing opposite ways. The wheel bearings carry the radial load of the vehicle's weight, plus the side-to-side load on the spindle.
5. Types of Wheel Bearing Failure	5. Examples/visuals of faulty wheel bearing components Causes of failure: • Improper maintenance • Lack of lubrication (moisture entry) • Overloading (exceeding load capacity)

Presentation Outline	Steps to Cover/Key Points to Make
6. Removing Bearings	6. Raise the vehicle and safely support it. Remove the wheel, grease cap, cotter pin, adjusting nut, and bearing retainer washer. ***Key Point:*** Discard the cotter pin. Never reuse a cotter pin. Since the cotter pin's job is crucial—to keep the adjuster nut, bearings, and hub/wheel attached to the spindle—a new cotter pin should always be used during repairs. Move hub from side to side, remove outer bearing assembly, and set parts aside. Reinstall the adjusting nut. Remove the brake caliper, and secure it so it does not hang by the flexible hose. Move the hub out against the nut, and catch the inner bearing on the nut, popping the bearing and grease seal out of the hub. Wipe off the bearing races and spindle.
7. Cleaning Bearings	7. Using a solvent tank, wash the bearings free of all lubricant. Dry off the bearings with a blow gun and compressed air. ***Note:*** Do not spin bearings.
8. Inspecting Bearings and Races	8. On bearings, look for— • pitting, wear, rust, chipping, misalignment, binding, and cracked or bent roller cages On bearing races, look for— • pitting, wear, rust, heat discoloration, cracks, hard spots, and abnormal wear patterns

Presentation Outline	Steps to Cover/Key Points to Make
9. Repacking Wheel Bearing: Manual Method	9. Importance of using specified grease (viscosity, temperature, pressure) Place a fair amount of grease in palm of non-dominant hand (e.g., left hand for right-handed people). Hold bearing in other hand, with larger end facing you. Drag larger end through a portion of the grease in your palm, forcing grease into race and around rollers. Repeat until grease is packed into entire race and around all rollers. ***Key Point:*** Grease should go between all rollers fully, and a high-temperature wheel bearing grease should be used.
10. Repacking Wheel Bearing: Automatic Packer	10. Place bearing into packer (refer to tool manufacturer's instructions for specific procedure). ***Key Point:*** Grease should go between all rollers fully, and a high-temperature wheel bearing grease should be used.
11. Replacing Races	11. Follow manufacturer's recommendations concerning specific replacement procedure and proper tools. Use brass punches to remove or install races when correct drivers are not available. Use aluminum driver or brass punch to drive bearing race from hub. Place drum/rotor on bench, with race to be driven out face-down. From open end of hub, drive race out. Install new race with bearing driver or brass punch.
12. Reinstalling Bearings and Replacing Seals	12. Lubricate races and inner hub with grease. Also lubricate spindle now. Place inner bearing in hub race. Install new grease seal per manufacturer's specifications.

Presentation Outline	Steps to Cover/Key Points to Make
13. Reinstalling Hub	13. Place drum/rotor on spindle. Install outer bearing into hub race. Install washer and retainer nut.
14. Adjusting Wheel Bearing	14. *Bearing preloading*—to load bearing into race to prevent movement General procedure: • Tighten nut hand-tight. • Back off nut 1/4 turn. • Retighten nut using thumb/forefinger. • Replace lock nut, if used. • ***Always*** install new cotter pin; bend excess ends around spindle to prevent loosening. • Install dust cap. Refer to manufacturer's adjustment procedures for specific vehicle.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher may demonstrate properties of different types of greases and/or special ingredients used to repack wheel bearing.

Review:

Ask students review questions such as the following:

1. How often should wheel bearings be serviced?
2. How can you tell whether a wheel bearing is adjusted properly?
3. Can chassis grease be used on front wheel bearings? Why or why not?
4. Why should the cotter pin always be replaced?
5. Why should steel punches or hammers ***not*** be used to perform this job?

Application:

1. Have students complete a teacher-prepared crossword puzzle of brake and bearing terminology.
2. Provide students with examples of faulty wheel bearing components, and have them identify the possible causes of the failure.
3. As students practice removing, inspecting, and servicing or replacing front and rear wheel bearings, quiz them individually on the process (e.g., ask them to summarize information about wheel bearing packing; outline the steps in the adjustment procedure; or point out evidence of pitting, wear, rust, etc., on the bearings or races).

Evaluation:

√ Each student will remove, clean, inspect, and service or replace front and rear wheel bearings (serviceable tapered roller bearings) and races; replace seals; reinstall the hub; and adjust wheel bearings. His/her performance will be evaluated using a copy of the performance checklist for Competencies 4.4.2/5.5.2/5.57.

Competency 4.4.2:	Remove, inspect, and service or replace front and rear wheel bearings
Competency 5.5.2:	Remove, clean, inspect, repack, and reinstall wheel bearings and replace seals; reinstall hub and adjust wheel bearings
Competency 5.5.7:	Replace wheel bearing and race

Performance Checklist

In removing, cleaning, inspecting, and servicing or replacing front and rear wheel bearings and races; replacing seals; reinstalling the hub; and adjusting wheel bearings, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Removed drum/rotor assembly in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
5. Removed/disassembled wheel bearings in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
6. Washed bearings free of all lubricant	☐	☐	☐	☐	☐
7. Dried bearings with blow gun and compressed air	☐	☐	☐	☐	☐
8. Determined whether repairs were needed	☐	☐	☐	☐	☐
9. Selected high-temperature grease as specified by manufacturer	☐	☐	☐	☐	☐
10. Packed new bearing with selected grease in the amount specified by the manufacturer	☐	☐	☐	☐	☐
11. Replaced race, if needed, in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
12. Replaced or reinstalled bearings in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
13. Reinstalled drum/rotor assembly in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
14. Adjusted wheel bearing preload in accordance with manufacturer's specifications	☐	☐	☐	☐	☐

15. Performed final visual inspections:

a. Checked condition of surfaces	☐	☐	☐	☐	☐
b. Checked for leaks	☐	☐	☐	☐	☐
c. Checked tightness of fasteners/fittings	☐	☐	☐	☐	☐
16. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name_______________________________________**Date**_____________

Unit 4: Suspension and Steering

Subunit 4.5: Wheel Alignment Diagnosis, Adjustment, and Repair

Competency 4.5.1:	Diagnose vehicle wander, drift, pull, hard steering, bump steer, memory steer, torque steer, and steering return problems; determine needed repairs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Diagnose vehicle wander, drift, pull, hard steering, bump steer, memory steer, torque steer, and steering return problems and determine needed repairs
Criteria:	In accordance with the criteria in the checklist for Competency 4.5.1

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when diagnosing vehicle wander, drift, pull, hard steering, bump steer, memory steer, torque steer, and steering return problems. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Discuss the importance of proper wheel alignment and how it relates to steering.
2. Explain symptoms customer might describe when describing steering problems.
3. Explain typical tire wear patterns associated with worn or broken suspension and/or steering components.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Steering Operation	2. Terms and definitions; for example: ◆ Caster ◆ Camber ◆ Toe-in/toe-out on turns ◆ SAI ◆ Included angle ◆ Scrub radius Alignment angles and how each relates to proper operation
3. Tools for Checking Alignment	3. Tools needed to perform an alignment (e.g., tie rod sleeve hook)
4. Inspecting Suspension/Steering Components	4. Procedure for identifying loose or worn suspension and/or steering components ***Note:*** Most components should have no up/down movement.
5. Checking/Changing Angles	5. Procedure for checking/changing angles for a specific vehicle ***Note:*** Procedure will vary from manufacturer to manufacturer.
6. Determining Needed Repairs	6. Using diagnostic information gathered, refer to service manuals to identify needed repairs.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher may address angles and how a specific angle setting may affect the steering operation.

Review:

Ask students review questions such as the following:

1. What is the difference between torque steer and memory steer?
2. Define *camber, caster,* and *toe-in/toe-out on turns.*
3. Which angle would be most likely to cause a pull or drift and tire wear at the same time?

Application:

1. Have students practice performing steering operation inspections and determining needed repairs.
2. As students practice diagnosing steering problems, quiz them individually on the process (e.g., ask them to explain the causes of bump steer, memory steer, torque steer, etc.).

Evaluation:

√ Each student will diagnose vehicle wander, drift, pull, hard steering, bump steer, memory steer, torque steer, and steering return problems and determine needed repairs. His/her performance will be evaluated using a copy of the performance checklist for Competency 4.5.1.

Competency 4.5.1: Diagnose vehicle wander, drift, pull, hard steering, bump steer, memory steer, torque steer, and steering return problems; determine needed repairs

Performance Checklist

In diagnosing steering problems and determining needed repairs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Performed complete visual inspection of steering components for evidence of mechanical failure	☐	☐	☐	☐	☐
5. Identified all instances of loose or worn suspension and/or steering components	☐	☐	☐	☐	☐
6. Checked/changed angles in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
7. Determined needed repairs	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 4: Suspension and Steering

Subunit 4.6: Wheel and Tire Diagnosis and Repair

Competency 4.6.1: Diagnose tire wear patterns; determine needed repairs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, various worn tires, and manufacturer's information; and while following all applicable safety guidelines
Behavior:	Diagnose tire wear patterns, and determine needed repairs
Criteria:	In accordance with the criteria in the checklist for Competency 4.6.1

Introduction:

General Introductory Techniques: Share personal experiences you have had when diagnosing tire wear patterns and determining needed repairs in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Explain concerns customer might describe related to observable tire wear.
2. Discuss how tire wear might affect the driveability of a vehicle (e.g., how it relates to wheel alignment and suspension problems).
3. Discuss vehicle inspection process and the role tire tread has in passing an inspection.
4. Explain importance of tire tread and the need to monitor tread depth. Ask students if they know minimum tire tread depth allowed by state law.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Tire Wear Patterns	2. Various types of tire wear Causes for each type of wear ***Note***: Commercially prepared transparencies of tire wear patterns are available.
3. Driver Safety	3. Dangers of traveling on worn tires How to determine when a tire is unsafe
4. Measuring Tread	4. Measure with depth gauge at lowest point found in tread area. Tires should have no less than 2/32" of tread. Some tires have *wear bars* formed into the tread. When tires near wear limit, bars in tread will be exposed to indicate that replacement is needed.
5. Determining Needed Repairs	5. Using diagnostic information gathered, refer to service manuals to identify needed repairs.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher may address measuring processes and using fractions. The applied science teacher may address how heat from traveling affects tire material(s).

Review:

Ask students review questions such as the following:

1. Which type of tire wear pattern would indicate that a car would pull to one side or drift?
2. If a tire is underinflated, how does this affect the tire's wear?
3. How do different types of tire wear (e.g., drift, pull, wander) affect the driveability of a vehicle?

Application:

1. Have students role-play instructing a customer in how to check and maintain proper inflation pressure to get the best ride and wear from the tires.
2. Set up stations, with each station having one used tire exhibiting wear caused by a different specific cause. Divide students into teams and have them rotate through the stations, inspecting each tire and identifying its degree of wear and wear pattern. Then have the teams compare their observations and results.

Evaluation:

√ Each student will diagnose tire wear patterns and determine needed repairs. His/her performance will be evaluated using a copy of the performance checklist for Competency 4.6.1.

Competency 4.6.1: Diagnose tire wear patterns; determine needed repairs

Performance Checklist

In diagnosing tire wear patterns and determining needed repairs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Performed complete visual inspection for wear, cupping, and/or damage	☐	☐	☐	☐	☐
5. Measured tire tread depth accurately	☐	☐	☐	☐	☐
6. Determined tire condition and needed repairs	☐	☐	☐	☐	☐
7. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competency 4.6.2: Inspect tires; check and adjust air pressure

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, various worn tires, and manufacturer's information; and while following all applicable safety guidelines
Behavior:	Inspect tires, and check and adjust air pressure
Criteria:	In accordance with the criteria in the checklist for Competency 4.6.2

Introduction:

General Introductory Techniques: Share personal experiences you have had when inspecting tires and checking and adjusting air pressure in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Explain benefits of keeping tires inflated according to manufacturer's suggested specifications (tire longevity, vehicle ride).
2. Review concerns customer might describe related to overinflation and underinflation of car tires.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Inspecting Tires for Damage	2. Characteristics that make a tire unsafe or affect the vehicle ride: • Cuts • Bruises • Dry rot • Uneven wear • Bulges • Cracks
3. Checking Air Pressure	3. Tire should be cold when air pressure is checked. A cold tire is one which has been driven less than 2 miles or which has not been driven for at least 3 hours. Place gauge to valve. Note reading.

Presentation Outline	Steps to Cover/Key Points to Make
4. Increasing/Decreasing Air Pressure	4. Locate tire pressure specifications (correct inflation): • Placard on the car, usually on the door jamb • Owner's manual • Shop manual Increase or decrease air pressure in accordance with manufacturer's specifications. Do not decrease pressure if tire is hot. Reading will be higher than normal with a hot tire.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher may address reading fractions on measuring tools, temperature/pressure relationships (e.g., Boyle's law, Charles's law), and conversion of pounds per square inch (psi) to kilopascals (kPa). The applied science teacher may discuss the relationship of pounds of pressure per square inch.

Review:

Ask students review questions such as the following:

1. Why is it important that a tire be cold when you are checking air pressure?
2. Where can correct tire pressure specifications be found?
3. How important is tire pressure to the longevity of a tire and the vehicle's performance?
4. How will an overinflated tire wear? Why?

Application:

1. Divide students into teams, and have them check the air pressure in a variety of mounted tires. Then have the teams compare their observations and results.
2. Have students determine what factors are involved in how the manufacturer decides what the tire pressure should be.

Evaluation:

√ Each student will inspect tires and check and adjust air pressure. His/her performance will be evaluated using a copy of the performance checklist for Competency 4.6.2.

Competency 4.6.2: Inspect tires; check and adjust air pressure

Performance Checklist

In inspecting tires and checking and adjusting air pressure, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Performed complete visual inspection of tires	☐	☐	☐	☐	☐
5. Checked air pressure in accordance with standard procedure	☐	☐	☐	☐	☐
6. Obtained accurate air pressure reading	☐	☐	☐	☐	☐
7. Adjusted air pressure to tire manufacturer's specifications	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competencies 4.6.4/4.6.9: Rotate tires; reinstall wheels; torque lug nuts

Competency Development Guide

Objective:

Condition:	Provided with a vehicle and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Rotate tires, reinstall wheels, and torque lug nuts
Criteria:	In accordance with the criteria in the checklist for Competencies 4.6.4/4.6.9

Introduction:

General Introductory Techniques: Share personal experiences you have had when rotating tires, reinstalling wheels, and torquing lug nuts in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Discuss longevity of tires that are properly rotated on the vehicle.
2. Review concerns customer might describe related to observable tire wear.
3. Discuss conditions caused by not rotating tires (e.g., heel and toe wear, tire noise).
4. Discuss safety problems that might occur when wheel lugs are not torqued correctly.
5. Explain how brakes can be affected by improper torque (e.g., pulsation, vibration).

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Rotating Tires	2. On a front-wheel-drive vehicle, tires may be rotated from front to rear only. On a rear-wheel-drive vehicle, may move front tires straight to rear. Rears may be crossed to other side and moved forward.
3. Torquing Lug Nuts	3. Torquing standards Cross patterns that should be used when torquing lug nuts Problems caused by not torquing lug nuts to suggested degree General procedure: • Place wheel on hub. • Install lug nuts with beveled side in toward wheel. • Tighten nuts hand-tight. • Locate torque specifications. • Tighten to specifications in cross pattern.
4. Checking Air Pressure	4. Tire should be cold when air pressure is checked. Place gauge to valve. Note reading.

Presentation Outline	Steps to Cover/Key Points to Make
5. Increasing/Decreasing Air Pressure	5. Locate tire pressure specifications (correct inflation). Increase or decrease air pressure in accordance with manufacturer's specifications. Do not decrease pressure if tire is hot. Reading will be higher than normal with a hot tire.

> ***Note:*** The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.
>
> For example, the applied science teacher may discuss continuous wear in one area of a tire and how rotating tires changes position of wear. The applied mathematics teacher could work with students on calculating torque (torque = force x distance).

Review:

Ask students review questions such as the following:

1. What problems can develop when tires are not rotated at suggested time intervals?
2. As a general rule of thumb, how often should tires be rotated on a vehicle?
3. How does properly timed tire rotation extend the life of a vehicle's tires?
4. How are brakes affected if wheel lugs are not torqued properly?
5. Who is responsible for ensuring that lug nuts are torqued correctly?
6. What are some possible hazards if lug nuts are not torqued?

Application:

1. Have students match tire rotation (cross) patterns to the correct vehicle (e.g., front-wheel drive, rear-wheel drive).
2. As students practice rotating tires, quiz them individually on the process (e.g., ask them to point out and describe evidence that the tires have not previously been rotated at the suggested time interval).
3. Have students design a diagram of the lug nut tightening sequence.
4. As students practice torquing lug nuts, quiz them individually on the process (e.g., ask them to summarize what can happen when lugs are not properly torqued).

Evaluation:

- √ Each student will rotate tires, reinstall wheels, and torque lug nuts. His/her performance will be evaluated using a copy of the performance checklist for Competencies 4.6.4/4.6.9.

Competencies 4.6.4/4.6.9: Rotate tires; reinstall wheels; torque lug nuts

Performance Checklist

In rotating tires, reinstalling wheels, and torquing lug nuts, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Removed wheel assembly in accordance with manufacturer's specifications and marked location	☐	☐	☐	☐	☐
5. Reinstalled wheel assembly in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
6. Torqued wheel lug nuts in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
7. Measured air pressure accurately	☐	☐	☐	☐	☐
8. Adjusted air pressure (if necessary) to tire manufacturer's specifications	☐	☐	☐	☐	☐
9. Performed final visual inspection	☐	☐	☐	☐	☐
10. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name_______________________________________**Date**______________

Competency 4.6.7: Balance wheel and tire assembly (static and dynamic)

Competency Development Guide

Objective:

Condition:	Provided with a vehicle and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Balance a wheel and tire assembly (static and dynamic)
Criteria:	In accordance with the criteria in the checklist for Competency 4.6.7

Introduction:

General Introductory Techniques: Share personal experiences you have had when balancing wheel and tire assemblies in the auto tech shop. Show videos that demonstrate the steps in this process.

Competency-Specific Information:

1. Discuss difference between tire balance problems and engine or drive train vibration.
2. Discuss symptoms customer might describe related to incorrect wheel balance.
3. Describe wear associated with out-of-balance tire (e.g., cupping, flat spots).

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Terminology	2. *Static* refers to balancing the tire when at rest (bubble balance)—equal distribution of weight around wheel. *Dynamic* refers to balancing while tire is in motion—equal distribution of weight on each side of the center line.
3. Installing Weights	3. General procedures: • Weights are hammered on with holding tabs between the tire and rim along the bead. • Some wheels may require stick-on weights.
4. Locating/Correcting Heavy Spots	4. Static imbalance: • Tire will rotate to heavy spot down if mounted vertically. • Weight is attached to wheel directly opposite heavy area. • Weight may be divided in half, with half placed on each side of wheel. Dynamic imbalance: • Causes wheel shimmy. • Weight attempts to pull the wheel/tire side-to-side while rotating. • Weights are placed 180° apart from each other—one on the inside, and the other on the outside.

Presentation Outline	Steps to Cover/Key Points to Make
5. Electronic Balancing	5. Most electronic balancers will check both static and dynamic balance and determine how much weight is needed where. General procedure: ◆ Check tire pressure. ◆ Set tire pressure to specifications if necessary. ◆ Mount wheel/tire on balancer spindle (refer to manufacturer's specifications). ◆ Remove old weights. ◆ Spin tire. ◆ Determine size and location of weights needed. ◆ Install weights. ◆ Spin tire. ◆ Repeat if necessary.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher may discuss the rationale for balancing the wheels of a vehicle.

Review:

Ask students review questions such as the following:

1. How can you determine whether a tire is out of balance?
2. What happens to vehicle performance when tires are not balanced?
3. As a general rule of thumb, when should tires be balanced?
4. How important is tire balance to the longevity and proper wear of the tire?

Application:

1. As students practice balancing a wheel and tire assembly, quiz them individually on the process (e.g., ask them to summarize what happens when tires are not properly balanced).
2. Have students design handouts, posters, etc., to alert customers to the effects on tires and ride if the wheel and tire assembly is not balanced correctly.

Evaluation:

√ Each student will balance a wheel and tire assembly (static and dynamic). His/her performance will be evaluated using a copy of the performance checklist for Competency 4.6.7.

Competency 4.6.7: Balance wheel and tire assembly (static and dynamic)

Performance Checklist

In balancing a wheel and tire assembly (static and dynamic), the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Checked balance to determine the weight(s) needed	☐	☐	☐	☐	☐
5. Installed appropriate weight(s) to balance tire	☐	☐	☐	☐	☐
6. Torqued wheel lugs in accordance with manufacturer's recommended procedures	☐	☐	☐	☐	☐
7. Performed final visual inspection	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

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Competency 5.1.4: Diagnose poor stopping, pulling, or dragging caused by problems in the hydraulic system; determine needed repairs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Diagnose poor stopping, pulling, or dragging caused by problems in the hydraulic system; and determine needed repairs
Criteria:	In accordance with the criteria in the checklist for Competency 5.1.4

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when diagnosing poor stopping, pulling, or dragging caused by problems in the hydraulic system. Show videos that demonstrate the steps in this process.

Competency-Specific Information:

1. Reinforce that—in terms of driver safety—brakes are one of the most important systems in an automobile.

2. Explain why today's brake systems have a dual hydraulic design, and why this is important.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Poor Stopping	2. Possible causes: • Air in brake system • Restricted lines or hoses • Master cylinder pushrod out of adjustment • External fluid leaks • Internal fluid leaks
3. Brakes Pulling	3. Symptom: Car veers to right or left when brake pedal is applied. Front brake pull—the "pull" will be a strong force felt on the steering wheel. Rear brake pull—the pull is usually only noticeable during hard stops, and one may lock up. Possible causes: • Frozen caliper or wheel cylinder piston • Grease- or fluid-coated linings (indicating some sort of seal leakage) • Leaking calipers or wheel cylinders • Faulty shoe adjuster assemblies • Over-buildup of brake lining dust • Kinked hydraulic hoses or lines • Loose wheel bearing • Control arm bushings

Presentation Outline	Steps to Cover/Key Points to Make
4. Brakes Dragging	4. Symptom: Brakes remain partially applied after releasing the brake pedal. Brakes will overheat if vehicle is driven very far. Brake fade (loss of friction due to heat) can occur. By feeling each wheel assembly, you may locate the "dragger," which will usually be abnormally hot and hotter than the others. Pressure testing: ◆ Install brake pressure gauge at caliper/wheel cylinder. ◆ Apply pressure to system. ◆ Note reading compared to other readings. ◆ Pressure should drop as soon as released. Possible causes: ◆ Frozen caliper or wheel cylinder pistons ◆ Bad caliper piston seals ◆ Fluid contamination ◆ Master cylinder problems ◆ Flexible hose collapsing on brake release that holds pressure to actuators
5. Determining Needed Repairs	5. Using diagnostic information gathered, refer to service manuals to identify needed repairs.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could work with students on Pascal's law/ hydraulics (P = FA).

Review:

Ask students review questions such as the following:

1. If there is dirt in the brake fluid, what effect would this have on a brake's hydraulic system?
2. If a flexible hydraulic brake hose collapses on brake pedal release, why does this cause the brake to drag?

Application:

1. Give students a teacher-prepared diagram of a hydraulic brake system, and have them label the components.
2. As students practice diagnosing poor stopping, pulling, or dragging caused by problems in the hydraulic system, quiz them individually on the process (e.g., ask them to list possible causes of the specific symptoms).

Evaluation:

√ Each student will diagnose poor stopping, pulling, or dragging caused by problems in the hydraulic system and determine needed repairs. His/her performance will be evaluated using a copy of the performance checklist for Competency 5.1.4.

Competency 5.1.4: Diagnose poor stopping, pulling, or dragging caused by problems in the hydraulic system; determine needed repairs

Performance Checklist

In diagnosing poor stopping, pulling, or dragging caused by problems in the hydraulic system and determining needed repairs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tools to use	☐	☐	☐	☐	☐
3. Identified the possible condition (poor stopping, pulling, dragging) through customer interview	☐	☐	☐	☐	☐
4. Verified the condition	☐	☐	☐	☐	☐
5. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
6. Inspected fluid for contaminants and levels	☐	☐	☐	☐	☐
7. Removed wheels to check for leak(s)	☐	☐	☐	☐	☐
8. Performed other checks/tests appropriate for identifying cause of specific condition	☐	☐	☐	☐	☐
9. Correctly identifying cause of condition	☐	☐	☐	☐	☐
10 Determined needed repairs	☐	☐	☐	☐	☐
11. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 5: Brakes

Subunit 5.1: Hydraulic System Diagnosis and Repair

Competency 5.1.8: Select, handle, store, and install brake fluids

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Select, handle, store, and install brake fluids
Criteria:	In accordance with the criteria in the checklist for Competency 5.1.8

Introduction:

General Introductory Techniques: Share personal experiences you have had when selecting, handling, storing, and installing brake fluids in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Give examples of how using the incorrect brake fluid can cause serious system damage.
2. Discuss properties of brake fluid, and demonstrate its effect on a painted surface.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safety & Vehicle Care Practices	2. Improper storage and handling of brake fluid can be dangerous (e.g., can cause injury to skin or blindness). Brake fluid can damage painted surfaces, so protect these areas accordingly.
3. Selecting Brake Fluid	3. Although DOT 3, DOT 4, and DOT 5 brake fluids have different characteristics and classifications, they must all do the same things: • Must maintain correct viscosity (i.e., must be free-flowing throughout all temperature ranges) • Must have a high boiling point (i.e., must not turn to a vapor at the highest system temperature). This is where the three types differ: Equilibrium Reflex Boiling Point (ERBP) ✓ DOT 3 has a dry ERBP of 401°F and a wet ERBP of 284°F. ✓ DOT 4 has a dry ERBP of 446°F and a wet ERBP of 356°F Those first two are the most common. ✓ DOT 5—a silicone-based fluid, which is ***not*** compatible with DOT 3 or 4—has a dry ERBP of 500°F and a wet ERBP of 356°F.

Presentation Outline	Steps to Cover/Key Points to Make
	• Must be noncorrosive (i.e., must not attack metal and rubber components) • Must be hygroscopic (i.e., water-tolerant, meaning the fluid will absorb moisture that collects in the system and suspend it so it doesn't boil) • Must lubricate (to reduce wear of valves, cup seals, and pistons) • Must have a low-temperature freezing point
4. Handling Brake Fluid	4. Keep fluid off hands and skin and out of eyes. Keep fluid away from painted surfaces.
5. Storing Brake Fluid	5. Keep containers tightly closed to keep out moisture from the atmosphere. Store in a cool, dry place. After container has been stored about 6 months, discard it in accordance with local regulations.
6. Installing Brake Fluid	6. Select the correct fluid type. Clean top of master cylinder lid to keep out any impurities. Add fluid to master cylinder in accordance with manufacturer's guidelines. As a rule of thumb, add fluid just to 1/4" from the top to allow for expansion. Don't overfill. Install cap. Close fluid container tightly.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher can provide information on brake fluid's chemical reactions to moisture, air, sunlight; effect on painted surfaces and skin.

Review:

Ask students review questions such as the following:

1. List four properties that all brake fluids should have.
2. What effect does moisture have on brake fluid?

Application:

1. Divide students into small groups, and assign each a particular vehicle. Have each group develop a procedure sheet on how to select and install brake fluid for the assigned vehicle. The procedure sheets should include all safety precautions per the manufacturer. Have students compare sheets and note commonalities and differences between procedures.
2. Have students practice installing brake fluids on several makes or models of vehicles to experience different procedures.

Evaluation:

√ Each student will select, handle, store, and install brake fluids. His/her performance will be evaluated using a copy of the performance checklist for Competency 5.1.8.

Competency 5.1.8: Select, handle, store, and install brake fluids

Performance Checklist

In selecting, handling, storing, and installing brake fluids, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Selected correct brake fluid	☐	☐	☐	☐	☐
5. Protected painted surfaces	☐	☐	☐	☐	☐
6. Filled brake fluid reservoir to proper level in accordance with manufacturers' specifications	☐	☐	☐	☐	☐
7. Sealed brake fluid container tightly	☐	☐	☐	☐	☐
8. Stored contained in a cool, dry place	☐	☐	☐	☐	☐
9. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 5: Brakes

Subunit 5.1: Hydraulic System Diagnosis and Repair

Competency 5.1.12: Bleed (manual, pressure, vacuum, or surge) brake system; flush hydraulic system

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Bleed a given brake system, and flush the hydraulic system
Criteria:	In accordance with the criteria in the checklist for Competency 5.1.12

Introduction:

General Introductory Techniques: Share personal experiences you have had when bleeding brake systems and flushing hydraulic systems in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. All air in the hydraulic system must be removed. This is done by a process called *bleeding*.

2. Because air can be compressed, it will not allow the hydraulic pressure to remain consistent and could cause system failure.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safety & Vehicle Care Practices	2. Improper storage and handling of brake fluid can be dangerous (e.g., can cause injury to skin or blindness). Brake fluid can damage painted surfaces, so protect these areas accordingly.
3. Pascal's Law/Hydraulics Fundamentals	3. Pascal stated that liquids cannot be compressed in a confined area, but they can be pressurized, and this pressure is transmitted equally in all directions. Thus, hydraulics can be used to increase or decrease force or motion. Air, since it is compressible, is the greatest enemy of a hydraulic system. Hydraulic pressure cannot be transmitted if there is air in the system. The brake pedal will feel "spongy," and a serious condition arises. To remove the air, you must *bleed* it out.

Presentation Outline	Steps to Cover/Key Points to Make
4. Manual Bleeding	4. Most commonly, you will need a helper. Bleed only one wheel at a time, following the manufacturer's sequence. Place bleeder jar and hose at bleeder screw. Have assistant "pump" pedal slowly several times to force air to the bleeder screw, and then hold pedal down. Open bleeder screw, allowing fluid/air to go into jar. When the flow stops, close the bleeder screw, and have the assistant release the pedal. Repeat this procedure until the fluid is clear and free of air bubbles. Move to next wheel in sequence, and repeat the procedure until all wheels have been bled and brake pedal is firm—not spongy any longer. Discard used brake fluid in accordance with local regulations. ***Never*** reuse used brake fluid. Make sure to fill master cylinder periodically (every 3–4 bleeds). Do ***not*** allow it to run out of fluid.
5. Pressure Bleeding	5. Can be performed by one person working alone. Fill bleeder tank to proper level, and pressurize it with shop air to specified air pressure: either psi (usually 10–15 psi) or kPa (usually 69–103 kPa). Fill master cylinder to proper level, and install bleeder adapter in accordance with manufacturer's guidelines. Following manufacturer's instructions, begin bleeding process in correct sequence. ***Note:*** You may need to open the metering valve assembly before bleeding to get all air from front brakes. Consult the service manual. Again, attach bleeder hose and jar as in manual bleeding. Open pressure bleeder valve on tank.

Presentation Outline	Steps to Cover/Key Points to Make
	Open brake bleeder screw until fluid is clear and free of air bubbles. Repeat procedure until brake pedal is firm. ***Key Point:*** Do not forget to remove the metering valve hold-open tool prior to driving. Discard used fluid properly.
6. Vacuum Bleeding	6. Can be performed with one person working alone. Fill master cylinder (check every 3–4 bleeds). Follow ***reverse*** of bleeding sequence. Attach vacuum bleeder to bleeder screw, pump vacuum pump to 20"Hg, and open bleeder screw. When vacuum pump gauge reads 0"Hg, close the bleeder. Repeat until all air is removed. Discard used fluid properly.
7. Flushing	7. Hydraulic system must be flushed every year for most anti-lock system (ABS) vehicles. Flushing can be done using any of the bleeding methods, but pressure flushing is the best method. Simply bleed each bleeder screw until there is new, fresh, clear fluid coming out. When completed, fill master cylinder to its correct level. Discard used fluid properly.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher can work with students on problems involving Pascal's law (P = FA). The applied science teacher can provide lessons on chemical reactions.

Review:

Ask students review questions such as the following:

1. True or False? Using old brake fluid over again is a standard procedure in the automobile service profession.

2. Describe in detail how to manually bleed a brake system.

Application:

1. Have each student list or diagram the correct bleeding sequence for a minimum of five different vehicles (each produced by a different manufacturer).

2. Hold a clinic for other classes to give students a chance to practice bleeding techniques.

Evaluation:

√ Each student will bleed a given brake system and flush the hydraulic system. His/her performance will be evaluated using a copy of the performance checklist for Competency 5.1.12.

Competency 5.1.12: Bleed (manual, pressure, vacuum, or surge) brake system; flush hydraulic system

Performance Checklist

In bleeding a given brake system and flushing the hydraulic system, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
3. Selected correct tool(s) to use	☐	☐	☐	☐	☐
4. Protected painted surfaces	☐	☐	☐	☐	☐
5. Selected appropriate bleeding method	☐	☐	☐	☐	☐
6. Flushed/bled hydraulic system in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
7. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 5: Brakes

Subunits 5.2/5.3: Drum/Disc Brake Diagnosis and Repair

Competencies 5.2.1/5.3.1: Diagnose poor stopping, noise, pulling, grabbing, dragging, or pedal pulsation problems; determine needed repairs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Diagnose poor stopping, noise, pulling, grabbing, dragging, or pedal pulsation problems, and determine needed repairs
Criteria:	In accordance with the criteria in the checklist for Competencies 5.2.1/5.3.1

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when diagnosing poor stopping, noise, pulling, grabbing, dragging, or pedal pulsation problems and determining needed repairs. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. When you are able to diagnose a problem correctly and efficiently, you save both the company and the customer time and trouble.

2. As you become more experienced in diagnosis, you will become "the one customers go to" for good service.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Poor Stopping	2. Symptoms: Takes too long to stop; feels like no brakes are there. Possible causes: ◆ Air in brake system ◆ Restricted lines or hoses ◆ Master cylinder pushrod adjustment needed ◆ External fluid leaks ◆ Internal fluid leaks ◆ No power assist
3. Noise	3. Listen to descriptions from owners and learn to interpret them correctly. Noises can include grinding, squeaks, and rattles. Possible causes of ***grinding:*** ◆ Usually metal-to-metal contact of pads/rotors or shoes/drums ◆ Could be gravel or dirt between lining and rotor or drum

Presentation Outline	Steps to Cover/Key Points to Make
	Possible causes of ***squeaks:*** • Glazed linings (hardened due to heat or poor-quality lining) • Unlubricated brake backing plate contact points • Foreign materials embedded into linings • Wear indicator on pads rubbing the rotor Possible causes of ***rattles:*** • Something is loose • Missing or broken anti-rattle clip or pads • Springs on shoes • Loose or disconnected parts in the brake assembly
4. Pulling	4. Symptom: Vehicle veers to right or left on stops. Pulling in rear brakes is usually only noticed during a hard stop, normally accompanied by wheel skid and lockup. Possible causes: • Hydraulic system damage, such as collapsing flexible hoses or a pinched line • Contaminated linings • Contaminated fluid • Loose caliper • Loose wheel bearing • Worn control arm/bushing • Seized wheel cylinder or caliper

Presentation Outline	Steps to Cover/Key Points to Make
5. Grabbing	5. Symptoms: Brakes apply too quickly, usually on light pedal application, making it very tough to stop slowly. Possible causes: • Vacuum booster malfunction • Brake fluid or grease (leaking rear axle seals) on linings • Worn brake linings • Faulty metering valve • Mechanical fault inside the brake assembly
6. Dragging	6. Symptoms: Brakes remain partially applied, even after releasing the brake pedal. Brakes will overheat if driven very far. Brake fade (loss of friction due to heat) can occur. To detect a "dragger," feel each wheel assembly. Usually the one dragging is much hotter than the others. Possible causes: • Frozen wheel cylinder pistons • Overadjusted or nonreleasing parking brake • Weak shoe return springs • Brake fluid contamination • Overadjusted master cylinder pushrod • Faulty master cylinder

Presentation Outline	Steps to Cover/Key Points to Make
7. Pedal Pulsation	7. Symptoms: Happens only when brake pedal is applied. Mostly felt in steering wheel but can also be felt in brake pedal or on floorboard. Possible causes: • Out-of-round drum • Out-of-round rim • Out-of-round rotor • Hard spots (due to heat) in the drum • Tire • Bent axle • Bent hub • Hub distortion
8. Determining Needed Repairs	8. Using diagnostic information gathered, refer to service manuals to identify needed repairs.

> ***Note:*** The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.
>
> For example, the applied science teacher could cover related concepts such as friction and inertia.

Review:

Ask students review questions such as the following:

1. If a customer complains about brakes dragging, what part could the master cylinder play in this problem?
2. If a brake pedal is pulsating, what could this mean? (List as many causes as you can.)
3. What is it called when a car tries to steer to the left or right when the brakes are applied?

Application:

1. Give students teacher-prepared diagrams of disc and drum brake systems, and have them label the components of each system.

2. Assign each student to one of three roles: customer, technician, or service advisor. Give each "customer" a list of brake system symptoms and complaints. Have each "technician" interview his/her customer to draw out the information needed and then work with the "service advisor" to identify possible causes of the problem. When they are done, have them switch roles and repeat the activity.

Evaluation:

√ The student will diagnose poor stopping, noise, pulling, grabbing, dragging or pedal pulsation problems and determine needed repairs. His/her performance will be evaluated using a copy of the performance checklist for Competencies 5.2.1/5.3.1.

Competencies 5.2.1/5.3.1: Diagnose poor stopping, noise, pulling, grabbing, dragging, or pedal pulsation problems; determine needed repairs

Performance Checklist

In diagnosing poor stopping, noise, pulling, grabbing, dragging or pedal pulsation problems and determining needed repairs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Secured needed information through customer interview	☐	☐	☐	☐	☐
5. Removed wheels and drums in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
6. Ensured that all brake dust was contained	☐	☐	☐	☐	☐
7. Performed complete visual inspection, as follows:					
a. Checked for leaks	☐	☐	☐	☐	☐
b. Checked gaskets	☐	☐	☐	☐	☐
c. Checked surface condition	☐	☐	☐	☐	☐
d. Checked wiring harnesses	☐	☐	☐	☐	☐
e. Checked fittings and fasteners	☐	☐	☐	☐	☐
f. Checked fluid type	☐	☐	☐	☐	☐
g. Checked fluid level	☐	☐	☐	☐	☐
8. Analyzed condition of individual components	☐	☐	☐	☐	☐
9. Correctly identified problem(s)	☐	☐	☐	☐	☐
10. Determined needed repairs	☐	☐	☐	☐	☐
11. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**_______________

Unit 5: Brakes

Subunit 5.2: Drum Brake Diagnosis and Repair

Competency 5.2.2: Remove, clean (using proper safety procedures), inspect, and measure brake drums; service or replace as needed

Competency Development Guide

Objective:

Condition: Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines

Behavior: Remove, clean, inspect, and measure brake drums; and service or replace as needed

Criteria: In accordance with the criteria in the checklist for Competency 5.2.2

Introduction:

General Introductory Techniques: Share personal experiences you have had when removing, cleaning, inspecting, measuring, servicing, and replacing brake drums in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. When making repairs to the drum brake assembly, you must first correctly and safely remove the drum.

2. Then you can inspect, clean, and measure the drum to see whether it can be used again.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling***. However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Asbestos is a cancer-causing agent and must be contained or suspended when you are working in and around brakes.
3. Removing Drum	3. Remove tire and wheel assemblies. Clean brake dust from drum area prior to removal, using recommended methods and safety procedures. If the drum is rusted to the axle hub flange, lightly tap ***between*** the lug studs with a hammer. You may need to back-off the adjuster if the drum is worn. Pull drum off, and clean it out immediately.
4. Inspecting Drum	4. Look for the following: • Obvious cracks • Missing areas around the rim • Hot spots

Presentation Outline	Steps to Cover/Key Points to Make
5. Measuring Drum	5. The drum should typically not be more than .060" or 1.5mm oversize or worn. If it is too large in diameter, it is too thin and may not dissipate (spread out and lose) the heat the system produces, thus causing brake fade. Measure the drum using a special brake drum micrometer and following the manufacturer's instructions. Such a micrometer will measure the drum accurately and quickly.
6. Replacing Drum	6. If the drum is found to be out of round or worn beyond the specifications stamped on it, it should be replaced.
7. Resurfacing Drum	7. If drum diameter is within specifications, resurfacing may be needed. Mount drum on lathe in accordance with manufacturer's specifications. Install vibration-dampening strap. Perform fast cut as needed. Remove as little as possible. Perform final slow cut. Remove and clean drum surface prior to reinstalling drum on vehicle.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could help students with micrometer readings.

Review:

Ask students review questions such as the following:

1. Why is it so important to contain or suspend brake dust fibers when you are removing a brake drum?
2. Brake drum specifications can be found on the drum. Where else can they be found?
3. What is an *out-of-round* brake drum, and how can you correct/repair it?

Application:

1. Set up six different vehicles, and divide the students into six teams. Have each team clean, remove, inspect, and measure the brake drums on one of the vehicles and record their findings.
2. As students practice removing, cleaning, inspecting, and measuring brake drums, quiz them individually on the process (e.g., ask them to describe in detail how to use the brake drum micrometer).

Evaluation:

√ Each student will remove, clean, inspect, and measure brake drums and service or replace as needed. His/her performance will be evaluated using a copy of the performance checklist for Competency 5.2.2.

Competency 5.2.2: Remove, clean (using proper safety procedures), inspect, and measure brake drums; service or replace as needed

Performance Checklist

In removing, cleaning, inspecting, and measuring brake drums and servicing or replacing as needed, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Removed brake drum in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
5. Ensured that all brake dust was contained	☐	☐	☐	☐	☐
6. Inspected/measured brake drum thoroughly	☐	☐	☐	☐	☐
7. Measured brake drum accurately	☐	☐	☐	☐	☐
8. Determined needed servicing/replacement	☐	☐	☐	☐	☐
9. Resurfaced or replaced brake drum in accordance with manufacturer's standards	☐	☐	☐	☐	☐
10. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name_______________________________________**Date**_____________

Unit 5: Brakes

Subunits 5.2/5.3: Drum/Disc Brake Diagnosis and Repair

Competencies 5.2.7/5.3.11: Reinstall wheel, torque lug nuts, and make final checks and adjustments

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Reinstall a wheel, torque the lug nuts, and make final checks and adjustments
Criteria:	In accordance with the criteria in the checklist for Competencies 5.2.7/5.3.11

Introduction:

General Introductory Techniques: Share personal experiences you have had when reinstalling wheels, torquing lug nuts, and making final checks and adjustments in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Technicians need to be able to assure each customer that his or her vehicle is road-ready when the job is finished.

2. No part of the job is more important than correctly reinstalling the wheel, torquing the lug nuts in the correct sequence, and making final checks and adjustments.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Making Drum Brake Adjustments	2. Preadjusting rear brakes: ◆ Use a brake shoe adjusting gauge to make your preadjustment in accordance with manufacturer's instructions. ◆ Then install the brake drum. With drum on— ◆ Use a brake spoon (star wheel tool) to turn the self-adjuster star wheel from a slot in the drum or backing plate. ◆ Simply turn the star wheel until the rotated drum just drags lightly. Adjusting parking brake: ◆ To adjust, you typically must move an adjustment nut on the parking brake cable. ◆ Always follow the manufacturer's instructions, as procedures will often vary from vehicle to vehicle.
3. Making Disc Brake Adjustments	3. Disc brakes are basically self-adjusting; however, you should check the following: ◆ Caliper bolt torque ◆ Wheel bearing adjustments ◆ Parking brake adjustments, if applicable

Presentation Outline	Steps to Cover/Key Points to Make
4. Checking Work	4. Go back over your work, ensuring that all items in the system have been replaced properly. Ask yourself after each job, "Would I drive this vehicle with my family in it?"
5. Reinstalling and Torquing Wheel	5. Lug nut torque is very important to the efficiency and safety of any vehicle. If lug nuts are torqued too tight, it can— ◆ cause stress of lug studs; ◆ distort hubs, rotors, and wheels beyond use; ◆ add to runout; and ◆ make the vehicle shake and vibrate, causing a possible loss of control. If lug nuts are undertorqued, the vehicle's wheel assembly could come off, creating a very dangerous situation (lack of control). Manufacturers suggest that lug nuts be tightened to specification using a torque wrench and following a particular pattern sequence. Consult shop information for both.
6. Performing Final Checks/Adjustments	6. Adjust tire air pressure as necessary. Double-check torque.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could provide lessons on transmitting mechanical force through gears, pulleys, cables, and levers.

Review:

Ask students review questions such as the following:

1. Why is it important to go back over your work ***before*** you install the wheels?
2. What does torquing lug nuts in a particular sequence matter on any given vehicle?
3. Where should you look to find torque specifications and tightening sequences for a particular vehicle?
4. Why is lug torque so important with disc brake–equipped vehicles?

Application:

1. Have students locate brake terms in a teacher-developed "Word Search."
2. Have students locate and list torque specifications for at least 10 vehicles of different makes.
3. As students practice reinstalling a wheel, torquing lug nuts,and making final checks and adjustments, quiz them individually on the process (e.g., ask them to show you where they located the tightening sequence for the vehicle).

Evaluation:

√ Each student will reinstall a wheel, torque the lug nuts, and make final checks and adjustments. His/her performance will be evaluated using a copy of the performance checklist for Competencies 5.2.7/5.3.11.

Competencies 5.2.7/5.3.11: Reinstall wheel, torque lug nuts, and make final checks and adjustments

Performance Checklist

In reinstalling a wheel, torquing the lug nuts, and making final checks and adjustments, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Adjusted shoe-to-drum clearance	☐	☐	☐	☐	☐
5. Reinstalled wheel in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
6. Adjusted parking brake	☐	☐	☐	☐	☐
7. Torqued lug nuts in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
8. Performed final inspection to verify work quality	☐	☐	☐	☐	☐
9. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competency 5.3.7: Clean, inspect, and measure rotor with a dial indicator and a micrometer; determine need to machine or replace

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Clean, inspect, and measure a rotor with a dial indicator and a micrometer; and determine the need to machine or replace
Criteria:	In accordance with the criteria in the checklist for Competency 5.3.7

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when cleaning, inspecting, and measuring rotors with a dial indicator and a micrometer and determining the need to machine or replace. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Technicians need to be able to correctly diagnose brake rotor conditions and indicate to the customer whether repair or replacement is recommended.

2. Manufacturers have set strict tolerances for thickness and runout. Too thin means trouble.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Cleaning Rotors	2. Using brake washer or spray brake cleaner, clean the entire surface and hub area. Scrape rust spots off ***inside*** of hub mounting areas so you don't reinstall an out-of-round condition due to rust buildup on a hub.
3. Performing Visual Inspection	3. Check rotors for the following: • Grooves • Pits • Blue/black appearance • Hub distortion
4. Measuring Runout	4. Using a dial indicator and following manufacturer's procedure, perform a brake disc runout check. *Brake disc runout* is the amount of side-to-side movement measured near the outer end of the outside friction surface of the rotor.
5. Determining Need to Repair	5. Compare the runout reading to the factory specifications. Typically, it should not exceed .004" (.10mm). If it is beyond the specs, the rotor should be machined on a brake rotor lathe.

Presentation Outline	Steps to Cover/Key Points to Make
6. Measuring Thickness	6. Brake disc thickness is measured across the rotor's two friction surfaces using an outside micrometer. Normally, you measure about 1" in from the outside of the rotor, and in four equally spaced places around the rotor. Consult the vehicle repair information for exaction locations specific to the vehicle.
7. Determining Need to Replace	7. Compare the thickness readings to the vehicle specifications. The specs are sometimes placed right on the hub areas of the rotor and will vary from make to make. Variation in disc thickness around the rotor indicates wear. If disc thickness is under specs (thinner), the disc should be replaced. A thin disc cannot dissipate (get rid of) heat quickly enough.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could work with students on making precision measurements (micrometers, dial indicators).

Review:

Ask students review questions such as the following:

1. What should you look for when visually inspecting a brake rotor?
2. What two tools are used to measure the rotor?
3. What term is used to describe the amount of side-to-side movement measured near the outer friction surface of a rotor?
4. What can happen if a brake rotor is too thin?

Application:

1. As students practice cleaning, inspecting, and measuring rotors with a dial indicator and a micrometer, quiz them individually on the process (e.g., ask them to describe in detail all necessary steps in diagnosing any brake rotor condition).

Evaluation:

- √ Each student will clean, inspect, and measure a rotor with a dial indicator and a micrometer and determine the need to machine or replace. His/her performance will be evaluated using a copy of the performance checklist for Competency 5.3.7.

Competency 5.3.7: Clean, inspect, and measure rotor with a dial indicator and a micrometer; follow manufacturer's recommendations in determining need to machine or replace

Performance Checklist

In cleaning, inspecting, and measuring a rotor with a dial indicator and a micrometer and determining the need to machine or replace, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Cleaned rotor thoroughly	☐	☐	☐	☐	☐
5. Performed complete visual inspection	☐	☐	☐	☐	☐
6. Measured runout in accordance with manufacturer's specifications using dial indicator	☐	☐	☐	☐	☐
7. Obtained accurate runout measurement	☐	☐	☐	☐	☐
8. Measured rotor thickness in accordance with manufacturer's specifications using micrometer	☐	☐	☐	☐	☐
9. Obtained accurate thickness measurement	☐	☐	☐	☐	☐
10. Determined need to machine or replace rotor	☐	☐	☐	☐	☐
11. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name_______________________________________**Date**_____________

Unit 5: Brakes

Subunit 5.3: Disc Brake Diagnosis and Repair

Competency 5.3.10: Fill master cylinder with recommended fluid, and seat pads; inspect caliper for leaks

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Fill a master cylinder with fluid, seat pads, and inspect the caliper for leaks
Criteria:	In accordance with the criteria in the checklist for Competency 5.3.10

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when filling master cylinders with fluid, seating pads, and inspecting calipers for leaks. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. By being careful to locate any and all sources of trouble, technicians are more likely to uncover problems such as a sticky caliper piston or fluid leaks in the disc brake system.

2. Ask students to name places where fluid could escape in the disc brake system.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Filling Master Cylinder	2. Make sure the master cylinder fluid level is appropriate for the task. Remember, as you collapse a caliper piston, the fluid behind it must go somewhere (back home, to the master cylinder). If the fluid level is low, leave it. If it is high, take some out using a syringe. ***Key Point:*** Dispose of this fluid; it is used and ***must not*** be reused. Consult local regulations in disposing of used brake fluid.
3. Seating Pads	3. Pump brake pedal 5–10 times to seat pads against rotor. Bend locking tabs on pads where applicable (refer to service manual).
4. Inspecting for Leaks	4. Check caliper housing and piston, seals, flex hose connection and hose, and tubing all the way back to and including the master cylinder.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science and mathematics teachers could work with students on Pascal's law, volume, area, and force.

Review:

Ask students review questions such as the following:

1. Where should you look to identify the correct fluid to add to the brake system?
2. Why shouldn't you add fluid to the master cylinder prior to seating pads?

Application:

1. Give students a teacher-prepared diagram of a disc brake system, and have them label the leak point possibilities.
2. As students practice filling a master cylinder with fluid, seating pads, and inspecting the caliper for leaks, quiz them individually on the process (e.g., ask them to explain the correct procedure for disposing of used brake fluid).

Evaluation:

√ Each student will fill a master cylinder with fluid, seat pads, and inspect the caliper for leaks. His/her performance will be evaluated using a copy of the performance checklist for Competency 5.3.10.

Competency 5.3.10: Fill master cylinder with recommended fluid, and seat pads; inspect caliper for leaks

Performance Checklist

In filling a master cylinder with fluid, seating pads, and inspecting the caliper for leaks, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Protected painted surfaces	☐	☐	☐	☐	☐
5. Selected brake fluid recommended by manufacturer	☐	☐	☐	☐	☐
6. Installed brake fluid in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
7. Pumped brake pedal to seat pads	☐	☐	☐	☐	☐
8. Performed final check of fluid reservoir	☐	☐	☐	☐	☐
9. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competency 5.5.1: Diagnose wheel bearing noises, wheel shimmy, and vibration problems; determine needed repairs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Diagnose wheel bearing noises, wheel shimmy, and vibration problems; and determine needed repairs
Criteria:	In accordance with the criteria in the checklist for Competency 5.5.1

Introduction:

General Introductory Techniques: Share personal experiences you have had when diagnosing wheel bearing noises, wheel shimmy, and vibration problems in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Ask students to define *shimmy* and give examples.
2. Describe what a wheel bearing noise sounds like.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Diagnosing Wheel Bearing Noise	2. Noises include growling and grinding; sounds as if there is a handful of gravel inside the wheel assembly. Rotate the wheels, feeling for roughness and noise symptoms. Removal for inspection may be necessary.
3. Diagnosing Wheel Shimmy and Vibration Problems	3. Shimmy is a condition in which the tire-wheel moves from side to side (looking at the front of the tire) and increasingly gets worse with speed increases, causing vibrations. Wheel bearings that are worn, loose, or improperly adjusted can cause shimmy. With vehicle off ground, grab tire/wheel assembly at top (12 o'clock) with one hand and the bottom (6 o'clock) with the other hand. Alternately move top and bottom of tire assembly in and out (toward and away from vehicle), feeling for any "play" or movement. Normally, if .004" movement occurs, the wheel bearings need attention, and further inspections are needed. Consult vehicle service information for specific procedures and specifications.

Presentation Outline	Steps to Cover/Key Points to Make
4. Determining Needed Repairs	4. Using diagnostic information gathered, refer to service manuals to identify needed repairs.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could work with students on precision measurement.

Review:

Ask students review questions such as the following:

1. If a wheel bearing becomes noisy, what are the possible causes?
2. How does wheel bearing adjustment affect shimmy and vibration?

Application:

1. Have each student develop a chart or checklist of items to look for when diagnosing wheel bearing troubles. Ask them to be specific and to place items in order of importance, with the most likely troubles first, and so on.
2. As students practice diagnosing wheel bearing noises, wheel shimmy, and vibration and determining needed repairs, quiz them individually on the process (e.g., ask them to explain the diagnostic procedure they are following).

Evaluation:

√ Each student will diagnose wheel bearing noises, wheel shimmy, and vibration problems and determine needed repairs. His/her performance will be evaluated using a copy of the performance checklist for Competency 5.5.1.

Competency 5.5.1: Diagnose wheel bearing noises, wheel shimmy, and vibration problems; determine needed repairs

Performance Checklist

In diagnosing wheel bearing noises, wheel shimmy, and vibration problems and determining needed repairs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Secured needed information through customer interview	☐	☐	☐	☐	☐
5. Inspected each of the following in accordance with manufacturer's specifications:					
a. Wheel bearings/races	☐	☐	☐	☐	☐
b. Hubs	☐	☐	☐	☐	☐
c. Drums	☐	☐	☐	☐	☐
d. Rotors	☐	☐	☐	☐	☐
6. Performed any other inspections necessary to identify problem	☐	☐	☐	☐	☐
7. Determined needed repairs	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name______________________________________**Date**____________

Unit 4: Suspension and Steering/Brakes

Subunits 4.4/5.5: Suspension Systems Diagnosis and Repair: Miscellaneous Service/ Miscellaneous (Wheel Bearings, Parking Brakes, Electrical, Etc.) Diagnosis and Repair

Competency 4.4.2:	Remove, inspect, and service or replace front and rear wheel bearings
Competency 5.5.2:	Remove, clean, inspect, repack, and reinstall wheel bearings and replace seals; reinstall hub and adjust wheel bearings
Competency 5.5.7:	Replace wheel bearing and race

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Remove, clean, inspect, and service or replace front and rear wheel bearings (serviceable tapered roller bearings) and races; replace seals; reinstall the hub; and adjust wheel bearings
Criteria:	In accordance with the criteria in the checklist for Competencies 4.4.2/5.5.2/ 5.5.7

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when removing, cleaning, inspecting, and servicing or replacing front and rear wheel bearings and races; replacing seals; reinstalling hubs; and adjusting wheel bearings. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Wheel bearing service is critical to any brake or suspension system repair.
2. Discuss why proper adjustment is necessary for good bearing performance and long life.
3. Explain the need for proper lubrication and adjustment of the front and rear wheel bearings and how this relates to proper vehicle operation.
4. Explain symptoms the customer might describe when a wheel bearing is not operating properly.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Safety concerns associated with improper lubrication or adjustment
3. Maintenance Schedule	3. Bearings should typically be serviced every 30,000 miles (refer to manufacturer's maintenance schedule for specific vehicle).
4. Use of Tapered Roller Bearings	4. Bearings are used in pairs, with tapers facing opposite ways. The wheel bearings carry the radial load of the vehicle's weight, plus the side-to-side load on the spindle.
5. Types of Wheel Bearing Failure	5. Examples/visuals of faulty wheel bearing components Causes of failure: • Improper maintenance • Lack of lubrication (moisture entry) • Overloading (exceeding load capacity)

Presentation Outline	Steps to Cover/Key Points to Make
6. Removing Bearings	6. Raise the vehicle and safely support it. Remove the wheel, grease cap, cotter pin, adjusting nut, and bearing retainer washer. ***Key Point:*** Discard the cotter pin. Never reuse a cotter pin. Since the cotter pin's job is crucial—to keep the adjuster nut, bearings, and hub/wheel attached to the spindle—a new cotter pin should always be used during repairs. Move hub from side to side, remove outer bearing assembly, and set parts aside. Reinstall the adjusting nut. Remove the brake caliper, and secure it so it does not hang by the flexible hose. Move the hub out against the nut, and catch the inner bearing on the nut, popping the bearing and grease seal out of the hub. Wipe off the bearing races and spindle.
7. Cleaning Bearings	7. Using a solvent tank, wash the bearings free of all lubricant. Dry off the bearings with a blow gun and compressed air. ***Note:*** Do not spin bearings.
8. Inspecting Bearings and Races	8. On bearings, look for— • pitting, wear, rust, chipping, misalignment, binding, and cracked or bent roller cages On bearing races, look for— • pitting, wear, rust, heat discoloration, cracks, hard spots, and abnormal wear patterns

Presentation Outline	Steps to Cover/Key Points to Make
9. Repacking Wheel Bearing: Manual Method	9. Importance of using specified grease (viscosity, temperature, pressure) Place a fair amount of grease in palm of non-dominant hand (e.g., left hand for right-handed people). Hold bearing in other hand, with larger end facing you. Drag larger end through a portion of the grease in your palm, forcing grease into race and around rollers. Repeat until grease is packed into entire race and around all rollers. ***Key Point:*** Grease should go between all rollers fully, and a high-temperature wheel bearing grease should be used.
10. Repacking Wheel Bearing: Automatic Packer	10. Place bearing into packer (refer to tool manufacturer's instructions for specific procedure). ***Key Point:*** Grease should go between all rollers fully, and a high-temperature wheel bearing grease should be used.
11. Replacing Races	11. Follow manufacturer's recommendations concerning specific replacement procedure and proper tools. Use brass punches to remove or install races when correct drivers are not available. Use aluminum driver or brass punch to drive bearing race from hub. Place drum/rotor on bench, with race to be driven out face-down. From open end of hub, drive race out. Install new race with bearing driver or brass punch.
12. Reinstalling Bearings and Replacing Seals	12. Lubricate races and inner hub with grease. Also lubricate spindle now. Place inner bearing in hub race. Install new grease seal per manufacturer's specifications.

Presentation Outline	Steps to Cover/Key Points to Make
13. Reinstalling Hub	13. Place drum/rotor on spindle. Install outer bearing into hub race. Install washer and retainer nut.
14. Adjusting Wheel Bearing	14. *Bearing preloading*—to load bearing into race to prevent movement General procedure: ◆ Tighten nut hand-tight. ◆ Back off nut 1/4 turn. ◆ Retighten nut using thumb/forefinger. ◆ Replace lock nut, if used. ◆ ***Always*** install new cotter pin; bend excess ends around spindle to prevent loosening. ◆ Install dust cap. Refer to manufacturer's adjustment procedures for specific vehicle.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher may demonstrate properties of different types of greases and/or special ingredients used to repack wheel bearing.

Review:

Ask students review questions such as the following:

1. How often should wheel bearings be serviced?
2. How can you tell whether a wheel bearing is adjusted properly?
3. Can chassis grease be used on front wheel bearings? Why or why not?
4. Why should the cotter pin always be replaced?
5. Why should steel punches or hammers ***not*** be used to perform this job?

Application:

1. Have students complete a teacher-prepared crossword puzzle of brake and bearing terminology.
2. Provide students with examples of faulty wheel bearing components, and have them identify the possible causes of the failure.
3. As students practice removing, inspecting, and servicing or replacing front and rear wheel bearings, quiz them individually on the process (e.g., ask them to summarize information about wheel bearing packing; outline the steps in the adjustment procedure; or point out evidence of pitting, wear, rust, etc., on the bearings or races).

Evaluation:

√ Each student will remove, clean, inspect, and service or replace front and rear wheel bearings (serviceable tapered roller bearings) and races; replace seals; reinstall the hub; and adjust wheel bearings. His/her performance will be evaluated using a copy of the performance checklist for Competencies 4.4.2/5.5.2/5.57.

Competency 4.4.2:	Remove, inspect, and service or replace front and rear wheel bearings
Competency 5.5.2:	Remove, clean, inspect, repack, and reinstall wheel bearings and replace seals; reinstall hub and adjust wheel bearings
Competency 5.5.7:	Replace wheel bearing and race

Performance Checklist

In removing, cleaning, inspecting, and servicing or replacing front and rear wheel bearings and races; replacing seals; reinstalling the hub; and adjusting wheel bearings, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Removed drum/rotor assembly in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
5. Removed/disassembled wheel bearings in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
6. Washed bearings free of all lubricant	☐	☐	☐	☐	☐
7. Dried bearings with blow gun and compressed air	☐	☐	☐	☐	☐
8. Determined whether repairs were needed	☐	☐	☐	☐	☐
9. Selected high-temperature grease as specified by manufacturer	☐	☐	☐	☐	☐
10. Packed new bearing with selected grease in the amount specified by the manufacturer	☐	☐	☐	☐	☐
11. Replaced race, if needed, in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
12. Replaced or reinstalled bearings in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
13. Reinstalled drum/rotor assembly in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
14. Adjusted wheel bearing preload in accordance with manufacturer's specifications	☐	☐	☐	☐	☐

15. Performed final visual inspections:

- a. Checked condition of surfaces ☐ ☐ ☐ ☐ ☐
- b. Checked for leaks ☐ ☐ ☐ ☐ ☐
- c. Checked tightness of fasteners/fittings ☐ ☐ ☐ ☐ ☐

16. Maintained clean work area ☐ ☐ ☐ ☐ ☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 5: Brakes

Subunit 5.5: Miscellaneous (Wheel Bearings, Parking Brakes, Electrical, Etc.) Diagnosis and Repair

Competency 5.5.4: Check parking brake operation; adjust as needed

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Check parking brake operation, and adjust as needed
Criteria:	In accordance with the criteria in the checklist for Competency 5.5.4

Introduction:

General Introductory Techniques: Share personal experiences you have had when checking and adjusting parking brake operation in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. It is critical that a vehicle's parking brake be in proper working order, because it may be the only thing holding the vehicle still when it is parked.

2. Explain how, in general, the parking brake operates.

3. Discuss whether parking brake should be applied on vehicles with automatic transmissions.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Inspecting Parking Brake	2. Apply parking brake. As a rule of thumb, the pedal or lever should not move more than about 65% (2/3) of full travel and hold the vehicle still in neutral. Inspect cables and linkage for problems such as the following: ◆ Rust ◆ Frozen parts ◆ Fraying ◆ Disconnected components Inspect pedal or lever mechanisms for damage.
3. Adjusting Parking Brake	3. Always follow manufacturer's procedures for adjustment. Check rear shoe-to-drum (or pad-to-rotor) clearance first, and adjust as needed. Check service manual to determine where to adjust parking brake. Make sure you lubricate all necessary points in the system with the recommended lubricant.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could provide lessons in the application of mechanical force through gears, pulleys, cables, and levers.

Review:

Ask students review questions such as the following:

1. Why is it important to keep the proper lubrication on parking brake cables? (List as many reasons as you can.)
2. How should you test the parking brake's operation?

Application:

1. Give students a teacher-prepared diagram of a parking brake, and have them label the components.
2. Have students locate and outline the parking brake adjustment procedures for two vehicles of different makes.

Evaluation:

√ Each student will check parking brake operation and adjust as needed. His/her performance will be evaluated using a copy of the performance checklist for Competency 5.5.4.

Competency 5.5.4: Check parking brake operation; adjust as needed

Performance Checklist

In checking parking brake operation and adjusting as needed, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Checked amount of travel in pedal or lever	☐	☐	☐	☐	☐
5. Inspected cables and linkage for damage	☐	☐	☐	☐	☐
6. Inspected pedal or lever mechanisms for damage	☐	☐	☐	☐	☐
7. Adjusted parking brake in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
8. Lubricated all necessary points using recommended lubricant	☐	☐	☐	☐	☐
9. Performed final visual inspection	☐	☐	☐	☐	☐
10. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name ____ **Date** ______________

Unit 5: Brakes

Subunit 5.5: Miscellaneous (Wheel Bearings, Parking Brakes, Electrical, Etc.) Diagnosis and Repair

Competency 5.5.6: Check operation of brake stop light system; adjust and service as needed

Competency Development Guide

Objective:

Condition: Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines

Behavior: Check the operation of a brake stop light system, and adjust and service it as needed

Criteria: In accordance with the criteria in the checklist for Competency 5.5.6

Introduction:

General Introductory Techniques: Share personal experiences you have had when checking, adjusting, and servicing brake stop light systems in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. If brake lamps are not operational, the driver's safety is at risk. Drivers behind him (or her) will not be alerted to the fact that he is slowing down or stopping.
2. Explain how this system operates with the transmission, cruise control, and ABS systems.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Stop Light System	2. Terminology Components of system (where pedal switch is, different types, etc.) System operation
3. Checking Operation	3. Simply push brake pedal while an assistant watches the stop lights at the rear of the vehicle to see whether they come on.
4. Identifying Causes of Problems	4. Possible causes: ◆ Burned-out lamp ◆ Defective switch ◆ Loose or corroded terminals or connections ◆ Defective battery ◆ Loose mounting Use circuit tester to troubleshoot specific circuit problem.
5. Adjusting System	5. Lights should illuminate after about 1/4"–1/2" pedal travel. Refer to service manual for adjustment procedure.

Presentation Outline	Steps to Cover/Key Points to Make
6. Servicing Inoperative Stop Lights	6. Check bulbs. Check for power to bulb. Check for bulb ground. Check for power to stop light switch. Check for continuity through switch. Check fuse.
7. Determining Needed Repairs	7. Using diagnostic information gathered, refer to service manuals to identify needed repairs.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could work with students on applications of Ohm's law.

Review:

Ask students review questions such as the following:

1. How does the brake stop light system operate?
2. If a brake stop light system is inoperative, what could be the possible causes of the problem?

Application:

1. Give students a teacher-prepared diagram of a brake stop light system, and have them label the components.
2. Give students written case studies describing different customer complaints about the brake stop light system (e.g., only one side of the stop light system works), and have them list the possible causes of each problem.

Evaluation:

√ Each student will check the operation of brake stop light system and adjust and service it as needed. His/her performance will be evaluated using a copy of the performance checklist for Competency 5.5.6.

Competency 5.5.6: Check operation of brake stop light system; adjust and service as needed

Performance Checklist

In checking the operation of a brake stop light system and adjusting and servicing it as needed, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Secured needed information through customer interview	☐	☐	☐	☐	☐
5. Verified whether lights were operational through simple visual check	☐	☐	☐	☐	☐
6. Determined cause of problem, performing each of the following checks as needed:					
a. Checked whether bulb was functional	☐	☐	☐	☐	☐
b. Checked circuit with circuit tester	☐	☐	☐	☐	☐
c. Checked for loose or corroded terminals or connections	☐	☐	☐	☐	☐
7. Adjusted/serviced system as needed in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
8. Performed final visual inspection	☐	☐	☐	☐	☐
9. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name______________________________________**Date**_____________

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Systems"
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Competency 6.1.1: Use wiring diagrams during diagnosis of electrical circuit problems

Competency Development Guide

Objective:

Condition:	Given a simple electrical circuit problem
Behavior:	Use a wiring diagram during the diagnosis of the problem
Criteria:	In accordance with the criteria in the checklist for Competency 6.1.1

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when using wiring diagrams during diagnosis of electrical circuit problems. Show videos that demonstrate the steps in this process.

Competency-Specific Information:

1. Ask students whether they have ever wondered how technicians determine how to fix the right wire in a car that has so many different wires. Explain that there's a road map for wires and that it's called a wiring diagram. By following the wiring diagram, you can fix most electrical problems.

2. Ask whether any students have ever installed a stereo system in a car? Did they use a wiring diagram?

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Note: There is a good deal of overlap in the competencies in this subunit. Competency 6.1.6 (now combined with 8.2.8) is where students focus on actually finding shorts, grounds, opens, and resistance problems in circuits and determining needed repairs. These earlier lessons should focus instead on how to use the ***tools*** for finding circuit problems: wiring diagrams, DMM, and ammeter.

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Safety in dealing with electricity
3. Atoms and Electrons	3. Number of electrons in atom Movement of electrons: ◆ Conventional flow—positive to negative ◆ Electron flow—negative to positive Conductors—allow flow of free electrons Insulators—resist or stop the flow of electricity Semi-conductors—can act as both a conductor or an insulator
4. Measurement of Electricity	4. Voltage = Unit for measuring electrical force or pressure Amperage/Current = Unit for measuring flow of electrons past a given point in a circuit Resistance/Ohms = Unit for measuring limits (controls) to current flow Wattage = Unit for measuring amount of work done by an electrical current (volts x amps)

Presentation Outline	Steps to Cover/Key Points to Make
5. Ohm's Law	5. Mathematical formula to show how voltage (E), amperage/current (I), and resistance/ohms (R) work together: • E = I x R • I = E ÷ R • R = E ÷ I
6. Wiring Diagrams	6. Wiring diagram = a road map of a circuit Purpose of using symbols to convey information: Saves time and space Common symbols and letter designations and the circuit components and wiring connections they represent Wire code identification system (wire size, color, numbers)
7. Types of Circuits	7. Demonstration of a simple circuit using a battery (power supply), wire (conductor), and bulb (load) Illustration of each of the following circuits using standard wiring diagram symbols: • Series (one path to ground) • Parallel (more than one path to ground) • Series-Parallel (combination of the two)
8. Conditions Affecting Normal Operation	8. Three conditions: • Open circuit, which is a break in the circuit • Shorted circuit, which allows flow around normal path or load • Grounded circuit, which allows current to return to the battery before the intended load

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

Throughout Unit 6, the applied science teacher could work with students on basic principles of electricity (volts, amps, ohms, watts, etc.), and the applied mathematics teacher could help students in solving problems using Ohm's law.

Review:

Ask students review questions such as the following:

1. What is the formula for Ohm's law, and what does it measure?
2. What is the difference between an insulator and a conductor?
3. What is the difference between a short circuit and an open circuit?
4. What is a semi-conductor?
5. What is the difference between a conductor and an insulator?

Application:

1. Give students teacher-developed worksheets requiring them to match symbols and letter designations with the components and wiring connections they represent.
2. Give students electrical diagrams with practice problems, and have them solve them using Ohm's law.

Evaluation:

√ Each student will use a wiring diagram during the diagnosis of a simple electrical circuit problem. His/her performance will be evaluated using a copy of the performance checklist for Competency 6.1.1.

Competency 6.1.1: Use wiring diagrams during diagnosis of electrical circuit problems

Performance Checklist

In using a wiring diagram during the diagnosis of a simple electrical circuit problem, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
3. Correctly interpreted wiring diagram symbols and letter designations	☐	☐	☐	☐	☐
4. Used wiring diagram to check each of the following items that might be causing electrical problem:					
a. Wires	☐	☐	☐	☐	☐
b. Connections	☐	☐	☐	☐	☐
c. Components	☐	☐	☐	☐	☐
5. Correctly interpreted information provided by wire code identification system	☐	☐	☐	☐	☐
6. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Units 6/8: Electrical/Electronic Systems/Engine Performance

Subunits 6.1/8.2: General Electrical System Diagnosis/Computerized Engine Controls Diagnosis and Repair

Competency 6.1.3:	Check voltage and voltage drop in electrical/electronic circuits using a digital multimeter (DMM); determine needed repairs
Competency 8.2.5:	Obtain and interpret digital multimeter (DMM) readings

Competency Development Guide

Objective:

Condition: Provided with an electrical/electronic circuit and while following all applicable safety guidelines

Behavior: Obtain and interpret DMM readings

Criteria: In accordance with the criteria in the checklist for Competencies 6.1.3/8.2.5

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when checking voltage and voltage drop using a DMM. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Explain that if there is one tool that today's technicians use in almost every area of the car, it is the digital multimeter (DMM).

2. Ask students to summarize the difference between an ampere and a volt.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

> ***Note:*** There is a good deal of overlap in the competencies in this subunit. Competency 6.1.6 (now combined with 8.2.8) is where students focus on actually finding shorts, grounds, opens, and resistance problems in circuits and determining needed repairs. These earlier lessons should focus instead on how to use the ***tools*** for finding circuit problems: wiring diagrams, DMM, and ammeter.

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Basic Electricity/Electronic Principles	2. Why we measure electricity How we measure electricity Key concepts/terms: • Load—an electrical device, such as a light bulb, that requires electrical current to operate. The voltage drops from one side of the load to the other. • Direct current—electricity travels one way. • Alternating current—electricity travels both ways. Review of other principles as needed (6.1.1)
3. Digital Multimeter (DMM)	3. DMM is a voltmeter, ammeter, and ohmmeter all in one. Also called a digital volt ohmmeter (DVOM). Allows you to obtain accurate measures of circuit values. By comparing the values obtained to known "good" values, you can identify problems.
4. Connecting DMM	4. Normal procedure for connecting DMM to circuit ***Remember:*** Keep leads away from moving parts.

Presentation Outline	Steps to Cover/Key Points to Make
5. Checking Voltage	5. Procedure for checking voltage using DMM, including— • Test on live circuits. • Set controls. • Hook meter in parallel to circuit. Power must be on.
6. Checking Resistance	6. Procedure for checking resistance using DMM, including— • Test on dead circuits. • Set controls. • Circuit must be isolated. Power must be off.
7. Checking Amperage	7. Procedure for checking amperage using DMM, including— • Use inductive clamps in series. • Set controls. • Hook up with inductive clamp or in series with the circuit being tested (make sure amperage rating of circuit does not exceed amperage rating of DMM). ***Caution:*** If amperage rating of circuit ***does*** exceed amperage rating of DMM, it could blow a fuse or damage the electrical circuits in DMM or, in severe cases, cause DMM to blow up. • Power to circuit should be on after tester is hooked up.

Presentation Outline	Steps to Cover/Key Points to Make
8. Identifying Voltage Drops	8. Definition: Voltage drop is the decrease in voltage as current passes through a resistance. Refer to manufacturer's specifications for voltage drops. Some manufacturers will specify different limits for ground voltage drops (500mv, 200mv, etc.) Formula for calculating voltage drop: • Ohm's law: $E = I \times R$ Method for measuring voltage drop across a resistance: • Check voltage going into the resistance, and compare it to the voltage coming out of the resistance. The difference is the voltage drop. • Amperage stays the same in a series circuit, but voltage is used in going through a resistance.
9. Interpreting Readings	9. High readings Low readings Open readings Zero readings

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

Throughout Unit 6, the applied science teacher could work with students on basic principles of electricity (volts, amps, ohms, watts, etc.), and the applied mathematics teacher could help students with metric units (micro, mili, kilo, mega, etc.) and in solving problems using Ohm's law.

Review:

Ask students review questions such as the following:

1. What is the proper use of a DMM on voltage, amperage, and ohm settings?
2. How should you connect the meter for voltage readings?
3. How much voltage is dropped before returning to the battery?
4. What does an infinite reading on the Ohm's scale mean?

Application:

1. Have students practice testing voltage drops across light bulbs or resistors using training modules. Change resistance by using opens and shorts.
2. Assign students a vehicle, and have them check for voltage drops across the accessible wiring connections on the engine compartment.
3. Give students a battery and a roll of wire with a load (light bulb) at one end, and have them check voltage drop in the length of wire.
4. Set up vehicle with headlights on and engine at 2,000 RPM, and have students use DMM to check for AC voltage at battery (max .4 volts AC).
5. Ask for a student volunteer. Strap pennies to the back of the student's hands with rubber bands, hook DMM to both pennies, and ask another student to identify the resistance reading (ohms). Ask student questions, while second student monitors changes in resistance readings. (This works as primitive lie detector test.)
6. Have students check current draw on an engine cooling fan.

Evaluation:

√ Each student will obtain and interpret DMM readings. His/her performance will be evaluated using a copy of the performance checklist for Competencies 6.1.3/8.2.5.

Competency 6.1.3: Check voltage and voltage drop in electrical/electronic circuits using a digital multimeter (DMM); determine needed repairs
Competency 8.2.5: Obtain and interpret digital multimeter (DMM) readings

Performance Checklist

In obtaining and interpreting DMM readings, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Connected DMM correctly to component being tested	☐	☐	☐	☐	☐
5. Measured each of the following using the DMM in accordance with standard procedure:					
a. Voltage	☐	☐	☐	☐	☐
b. Amperage/current	☐	☐	☐	☐	☐
c. Resistance/ohms	☐	☐	☐	☐	☐
d. Voltage drop	☐	☐	☐	☐	☐
6. Obtained accurate readings	☐	☐	☐	☐	☐
7. Compared values obtained to known "good" values	☐	☐	☐	☐	☐
8. Interpreted readings accurately	☐	☐	☐	☐	☐
9. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name_______________________________________**Date**______________

Unit 6: Electrical/Electronic Systems

Subunit 6.1: General Electrical System Diagnosis

Competency 6.1.4: Check current flow in electrical/electronic circuits and components using an ammeter; determine needed repairs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Check current flow in electrical/electronic circuits and components using an ammeter
Criteria:	In accordance with the criteria in the checklist for Competency 6.1.4

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when checking current flow in electrical/electronic circuits and components using an ammeter. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Indicate that although Ohm's law can be used to determine the amount of current going through a circuit, sometimes there is no substitute for making direct measurements (ammeter).

2. Explain importance of ensuring correct current flow in electrical/electronic circuits.

3. Ask students: What causes a fuse to blow? Can a bad component cause this to happen?

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Note: There is a good deal of overlap in the competencies in this subunit. Competency 6.1.6 (now combined with 8.2.8) is where students focus on actually finding shorts, grounds, opens, and resistance problems in circuits and determining needed repairs. These earlier lessons should focus instead on how to use the ***tools*** for finding circuit problems: wiring diagrams, DMM, and ammeter.

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Safety in dealing with electricity
3. Electricity Principles	3. Review of principles as needed (6.1.1), particularly— • Amperage/current—unit for measuring flow of electrons past a given point in a circuit
4. Ammeter	4. Purpose of ammeter Types of ammeter: • Digital vs. analog • Series hookup vs. inductive pickup Inductive pickup—infers amount of current going through wire by measuring strength of magnetic field around wire Inductive multiplier— multiplies the effective range of an inductive pickup using coils of wire placed around the wire being tested

Presentation Outline	Steps to Cover/Key Points to Make
5. Using Ammeter to Check Amperage	5. Must install ammeter in series or with magnetic pickup. Operate circuit as normal, and read gauge. Compare readings to manufacturer's specifications. If amp draw is too high, there is low resistance (possible short to ground). If amp draw is too low, there is too much resistance.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

Throughout Unit 6, the applied science teacher could work with students on basic principles of electricity (volts, amps, ohms, watts, etc.), and the applied mathematics teacher could help students in solving problems using Ohm's law.

Review:

Ask students review questions such as the following:

1. What could cause the amperage of a circuit to be too high?
2. What are the steps for installing an ammeter into a circuit?
3. What procedure should you use to hook up an ammeter in series? with a magnetic pickup?

Application:

1. Have students practice installing an ammeter into a circuit.
2. Have students simulate loose or corroded connections.
3. Have students use an ammeter to determine current draw for a parking light, a brake light, and both lights combined.
4. Have students build an inductive pickup multiplier and check it using an analog ammeter.
5. Have students use an ammeter to determine current draw for a headlight on low beam and for a headline on high beam.

Evaluation:

- √ Each student will check current flow in electrical/electronic circuits and components using an ammeter. His/her performance will be evaluated using a copy of the performance checklist for Competency 6.1.4.

Competency 6.1.4: Check current flow in electrical/electronic circuits and components using an ammeter; determine needed repairs

Performance Checklist

In checking current flow in electrical/electronic circuits and components using an ammeter, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Correctly installed ammeter in series or with magnetic pickup	☐	☐	☐	☐	☐
5. Checked current flow in electrical circuits/components using ammeter in accordance with standard procedure	☐	☐	☐	☐	☐
6. Obtained accurate results from all checks	☐	☐	☐	☐	☐
7. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name ____ **Date** ______________

Units 6/8: Electrical/Electronic Systems/Engine Performance

Subunits 6.1/8.2: General Electrical System Diagnosis/Computerized Engine Controls Diagnosis and Repair

Competency 6.1.6:	Find shorts, grounds, opens, and resistance problems in electrical/electronic circuits; determine needed repairs
Competency 8.2.8:	Inspect and test power and ground circuits and connections; service or replace as needed

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Find shorts, grounds, opens, and resistance problems in electrical/electronic circuits, and determine needed repairs
Criteria:	In accordance with the criteria in the checklist for Competencies 6.1.6/8.2.8

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when finding problems in electrical/electronic circuits and determining needed repairs. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Have students lead a review of electricity principles, use of Ohm's law, and proper use of diagnostic equipment (DMM, ammeter) and wiring diagrams.

2. If you can't find the electrical problem, you can't fix it. Replacing all parts in an electrical circuit is an expensive way to repair electrical circuits—and illegal, too. A good electrical diagnostician is always in demand in this industry.

3. To accurately test a circuit, you need to check the power and ground system in order to reduce incorrect diagnoses. Poor grounds can cause circuit and component failure. Poor power supplies can cause improper circuit operation.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Note: Earlier competencies in Subunit 6.1 focused on the skills and tools used in diagnosis. This lesson should focus on putting these skills together and selecting the right tools to use.

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical References	2. Refer to TSBs and schematics for system being tested in order to understand the fault and the system in which the fault is occurring.
3. Methods for Diagnosing a Circuit	3. Check source voltage. Check fuses. Check for power at component. Check for ground at component.
4. Using Test Light	4. Types of test lights (circuit-powered, self-powered) Procedure for using test light to check circuit for power, including— • One end of test light must be hooked up to a known good ground, with the other end used to probe for power source. Procedure for using test light to check circuit for ground, including— • One end of test light must be hooked up to a known good power, with the other end used to probe for ground. Procedure for using test light to find shorts ***Caution:*** Don't use a test light that has a high amp draw on computer circuits as this could damage the computer.

Presentation Outline	**Steps to Cover/Key Points to Make**
5. Checking a Power Supply Circuit	5. Tester on VOLT setting Negative to ground Positive to circuit being tested Should show system voltage (5v, 12v, etc.)
6. Checking a Ground Circuit	6. Tester on VOLT setting Negative to ground Positive to circuit being tested Should show 0v or below 500mv
7. Diagnosing Problems *One option would be to set up circuits with shorts, grounds, opens, and resistance problems and use these as examples as you walk students through the diagnostic process.*	7. Diagnostic process: • Select and use appropriate test equipment. • Refer to appropriate wiring diagrams. • Use Ohm's law. • Isolate the problem using separating connectors. • Identify problem.
8. Determining Needed Repairs	8. Using diagnostic information gathered, refer to service manuals to identify needed repairs.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

Throughout Unit 6, the applied science teacher could work with students on basic principles of electricity (volts, amps, ohms, watts, etc.), and the applied mathematics teacher could help students in solving problems using Ohm's law.

Review:

Ask students review questions such as the following:

1. Do corrosion or poor connections cause high amps to blow fuses?
2. Is it hard to find a short to ground? Why or why not?
3. What is the rule of thumb for an acceptable ground circuit voltage drop?
4. If you get a high voltage reading (above 500mv) when testing the grounds, what might this indicate?

Application:

1. Build circuit problems into training aids, and have students use wiring diagrams to diagnose the problems.
2. Use a wiring diagram to indicate a vehicle fault (perhaps an open on a parking lamp), and have students indicate what test light and/or DMM readings they think this fault would produce. Then have students introduce the fault into the vehicle and determine the actual reading it produces.
3. Give students a wiring diagram and information about a vehicle with an open on a circuit, and have them indicate the procedures and tests they would use to find where the potential faults could be.

Evaluation:

√ Each student will find shorts, grounds, opens, and resistance problems in electrical/electronic circuits and determine needed repairs. His/her performance will be evaluated using a copy of the performance checklist for Competencies 6.1.6/8.2.8.

Competency 6.1.6:	Find shorts, grounds, opens, and resistance problems in electrical/electronic circuits; determine needed repairs
Competency 8.2.8:	Inspect and test power and ground circuits and connections; service or replace as needed

Performance Checklist

In finding problems in electrical/electronic circuits and determining needed repairs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
3. Selected correct diagnostic tool(s) for checking circuit	☐	☐	☐	☐	☐
4. Attached test equipment in accordance with established procedures	☐	☐	☐	☐	☐
5. Obtained accurate results from all tests	☐	☐	☐	☐	☐
6. Used wiring diagrams to aid diagnosis	☐	☐	☐	☐	☐
7. Correctly interpreted wiring diagrams	☐	☐	☐	☐	☐
8. Identified shorts, grounds, opens, and resistance problems	☐	☐	☐	☐	☐
9. Determined needed repair	☐	☐	☐	☐	☐
10. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 6: Electrical/Electronic Systems

Subunit 6.1: General Electrical System Diagnosis

Competency 6.1.7: Measure and diagnose the cause(s) of abnormal key-off battery drain; determine needed repairs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Measure and diagnose the cause(s) of abnormal key-off battery drain, and determine needed repairs
Criteria:	In accordance with the criteria in the checklist for Competency 6.1.7

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when measuring and diagnosing the cause(s) of abnormal key-off battery drain and determining needed repairs. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Ask students: How many times have you had a car that didn't want to start in the morning? Was it due to lights being left on or was the cause unknown?
2. Ask students if they have ever heard of someone putting a new battery in a car only to have the battery go dead?

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Safety related to battery (acid, electricity)
3. Diagnosing Causes of Abnormal Drain	3. Disconnect negative battery cable. Connect ammeter in series per manufacturer's specifications. General guidelines: • Readings of 0.020–0.030 amps are normal. • Readings of 0.050 amp or greater should be found and corrected.
4. Dealing with Abnormal Drain	4. Disconnect lights under hood, in glove box, in trunk. If abnormal drain is still present, remove one fuse at a time until you find failed circuit. Then, disconnect power connectors in that circuit until the problem is located.
5. Determining Needed Repairs	5. Using diagnostic information gathered, refer to service manuals to identify needed repairs.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

Throughout Unit 6, the applied science teacher could work with students on basic principles of electricity (volts, amps, ohms, watts, etc.), and the applied mathematics teacher could help students in solving problems using Ohm's law.

Review:

Ask students review questions such as the following:

1. What steps should you follow to verify the repair?
2. What other circuits are affected that are protected by the fuse?
3. What is the difference between 100 milliamps and .100 amps?

Application:

1. Ask students to use an ammeter to read the computer drain for a vehicle. Have them note drain both with key on and key off and also note how many seconds it takes for computer and accessories to shut back down after key off.
2. Have students leave dome light on and then read current draw. Then have them pull fuses until current draw goes to specifications. Ask them to note which fuse controls dome light.

Evaluation:

√ Each student will measure and diagnose the cause(s) of abnormal key-off battery drain and determine needed repairs. His/her performance will be evaluated using a copy of the performance checklist for Competency 6.1.7.

Competency 6.1.7: Measure and diagnose the cause(s) of abnormal key-off battery drain; determine needed repairs

Performance Checklist

In measuring and diagnosing the cause(s) of abnormal key-off battery drain and determining needed repairs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Measured battery drain with key turned to off position	☐	☐	☐	☐	☐
5. Followed standard procedures for locating abnormal drain	☐	☐	☐	☐	☐
6. Connected ammeter correctly	☐	☐	☐	☐	☐
7. Obtained accurate ammeter readings	☐	☐	☐	☐	☐
8. Analyzed results to determine needed repairs	☐	☐	☐	☐	☐
9. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name ____ **Date** ______________

Unit 6: Electrical/Electronic Systems

Subunit 6.1: General Electrical System Diagnosis

Competency 6.1.8:	Inspect and test fusible links, circuit breakers, and fuses; replace as needed

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Inspect and test fusible links, circuit breakers, and fuses; and replace them as needed
Criteria:	In accordance with the criteria in the checklist for Competency 6.1.8

Introduction:

General Introductory Techniques: Share personal experiences you have had when inspecting, testing, and replacing fusible links, circuit breakers, and fuses in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Ask students: How many times have you had a car radio just stop working? Was it due to the amplifier you just installed so you can feel the music?

2. Ask students: Have you ever heard a pop noise from the dash, following which the dome lights stop working? What do you think was the cause?

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Do not put unprotected wire into fuse block.
3. Testing Fuses	3. Types of fuses: glass, blade, mini, ceramic (maxi or cartridge fuses are frequently used in place of fusible links) Fuses are rated in amps and volts. ***Note:*** You can determine whether a fuse is appropriate for a particular circuit using the formula for fuse rating: approximately 1.2 x current draw. Testing methods: ◆ Use test light to test power on both sides without removing from fuse block. ◆ Remove fuse, and check it with an ohmmeter. It should read 0 ohms.
4. Testing Fusible Links	4. Check condition of outside insulation. Use test light to back-probe at connections into and out of fusible link. Solder fusible link into circuit if replacing link. Use non-acid-core solder if wire is copper. Do not solder aluminum wiring.

Presentation Outline	Steps to Cover/Key Points to Make
5. Testing Circuit Breakers	5. Use test light to test power into and out of circuit breakers. Check amp draw of circuit. Compare reading to amp rating of breaker. Check whether it is overheated.
6. Diagnosing Circuit	6. Circuit protectors fail because of a reason. Common causes of failure: ◆ Short to ground ◆ Shunt around a load in a circuit ◆ Excess current draw in motor (fan) Shorts may require the use of a circuit breaker to diagnose the circuit. Follow manufacturer's procedures to correct problem.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

Throughout Unit 6, the applied science teacher could work with students on basic principles of electricity (volts, amps, ohms, watts, etc.), and the applied mathematics teacher could help students in solving problems using Ohm's law.

Review:

Ask students review questions such as the following:

1. Under what conditions do fusible links, circuit breakers, and fuses fail?
2. What are the different types of fuses?
3. Describe two ways of checking whether a fuse is good or bad.
4. What are the different types of circuit protection devices?
5. What is the formula for determining the fuse rating of a circuit?

Application:

1. Have students remove fuses, one at a time, and determine the fuse rating. Ask them to inspect each fuse with an ohmmeter or DMM and determine which circuits the fuse protects.
2. Give students a wiring diagram, and have them indicate the location of all fuses in the vehicle.
3. Have students measure current draw for a lamp or fan and then determine what size fuse should be used to protect that circuit.

Evaluation:

√ Each student will inspect and test fusible links, circuit breakers, and fuses and replace them as needed. His/her performance will be evaluated using a copy of the performance checklist for Competency 6.1.8.

Competency 6.1.8: Inspect and test fusible links, circuit breakers, and fuses; replace as needed

Performance Checklist

In inspecting and testing fusible links, circuit breakers, and fuses and replacing them as needed, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Inspected fusible links, circuit breakers, and fuses according to established procedures	☐	☐	☐	☐	☐
5. Checked fusible links, circuit breakers, and fuses using appropriate test equipment	☐	☐	☐	☐	☐
6. Determined components that needed to be replaced	☐	☐	☐	☐	☐
7. Replaced components in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
8. Rechecked electrical system to verify operation	☐	☐	☐	☐	☐
9. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 6: Electrical/Electronic Systems

Subunit 6.1: General Electrical System Diagnosis

Competency 6.1.9: Inspect and test switches, connectors, relays, and wires of electrical/electronic circuits; repair or replace as needed

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Inspect and test circuit switches, connectors, relays, and wires; and repair or replace them as needed
Criteria:	In accordance with the criteria in the checklist for Competency 6.1.9

Introduction:

General Introductory Techniques: Share personal experiences you have had when inspecting, testing, and repairing/replacing circuit switches, connectors, relays, and wires in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Replacing a horn won't always repair the problem; you may need to check and repair the wires, connectors, relays, and switches in the horn circuit. Finding the problem is often a lot harder than fixing the problem.
2. Ask students: How does the horn or blower motor circuit handle the amp load?
3. Ask students: How do you diagnose switches and relays?

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Do not replace fuse with jumper wire. Do not pierce wires!!! Do not use test light to check for power on any computer-controlled circuit or relays controlled by the computer. The extra amp draw of the test light can damage circuits.
3. Testing Wire Circuits	3. Types of wire: copper, aluminum, twisted shield, or computer wire Testing procedure: • Use ohmmeter, continuity tester. • Measure resistance in circuit, and compare against manufacturer's specifications. It must not exceed manufacturer's specifications. • Do not pierce wires.

Presentation Outline	Steps to Cover/Key Points to Make
4. Testing Connectors	4. Difference between a terminal and connector: • Terminal fits on the end of a wire. • Connector holds the terminals. Types of connectors: molded, hard-shell, bulkhead, weather-pack, metri-pack Testing procedure: • Back-probe into connectors. • Visually inspect connectors. • Look for corrosion damage or voltage drop. • Do not pierce wires.
5. Testing Switches	5. Switch classifications: • NO—normally open • NC—normally closed Testing procedure: • Check continuity—open and closed positions. • Check for power into and out of switches.
6. Testing Relays	6. Relays—use a small current to control a larger current Relay classifications: • NO—normally open • NC—normally closed Testing procedure: • Check for power into relays. • Check signal power from controller. • Check ground. • Check component that is controlled.

Presentation Outline	Steps to Cover/Key Points to Make
7. Making Repairs	7. Follow manufacturer's specifications to correct problems. Wires: • Determine size and type of conductor. • Replace wire with wire of the same type and same diameter or larger. Terminals: • Crimping is acceptable for wire not exposed to weather. • Solder terminals exposed to weather on copper wires. • Do not solder aluminum wire to terminals. Twisted shield or computer wires: • Stagger splice connections. • Solder all splices. • Tape individual wires with Mylar tape, but leave drain wire exposed. • Use electric tape, or heat-shrink tube to insulate cable and drain wire. Molded connectors: • Not repairable; wires must be spliced into a new connector. Hard-shell, bulkhead, weather-pack, and metri-pack connectors: • Use pick or special tool to release terminals. • Replace connector.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

Throughout Unit 6, the applied science teacher could work with students on basic principles of electricity (volts, amps, ohms, watts, etc.), and the applied mathematics teacher could help students in solving problems using Ohm's law.

Review:

Ask students review questions such as the following:

1. Under what conditions do relays fail to work?
2. What tools prove most useful in conducting these tests?
3. Why shouldn't test lights be used to check computer-controlled circuits?
4. What is the job of a relay? How are relays classified?
5. Why can't you pierce the wires in an electrical circuit?

Application:

1. Give students a vehicle with a relay, and have them determine whether the relay is classified NC or NO.
2. Have students practice crimping terminals on wires and then soldering terminals onto wires. Ask them to place the wires in a circuit and then check connections with a voltage drop test.
3. Have students remove and reinstall connectors and then verify the operation of all circuits going through the connectors.
4. Give students a wiring diagram of a circuit; have them locate all the switches, wires, and relays; and then have ask them to describe the procedures they would use for accessing all switches, wires, and relays in the circuit for testing.
5. Give students a wiring diagram, and have them locate all wires and electrical items in a single circuit.

Evaluation:

√ Each student will inspect and test circuit switches, connectors, relays, and wires and repair or replace them as needed. His/her performance will be evaluated using a copy of the performance checklist for Competency 6.1.9.

Competency 6.1.9: Inspect and test switches, connectors, relays, and wires of electrical/electronic circuits; repair or replace as needed

Performance Checklist

In inspecting and testing circuit switches, connectors, relays, and wires and repairing or replacing as needed, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Performed visual inspection of each component (switches, connectors, relays, and wires) according to established procedures	☐	☐	☐	☐	☐
5. Tested each component for proper operation	☐	☐	☐	☐	☐
6. Analyzed test results	☐	☐	☐	☐	☐
7. Determined components that needed to be replaced	☐	☐	☐	☐	☐
8. Replaced components in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
9. Rechecked electrical system to verify operation	☐	☐	☐	☐	☐
10. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 6: Electrical/Electronic Systems

Subunit 6.2: Battery Diagnosis and Service

Competency 6.2.1: Perform battery state-of-charge test; determine needed service

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Perform battery state-of-charge test, and determine needed service
Criteria:	In accordance with the criteria in the checklist for Competency 6.2.1

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when performing battery state-of-charge tests and determining needed service. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. If a battery is weak, this can also affect the computers, causing the vehicle to run rough or the transmission not to shift correctly. Thus, it is important to determine the battery's state of charge before starting to look for more complicated electronic problems.

2. Ask students: If a battery is dead, how can you determine whether the battery is bad or the dead battery was caused by some other problem (e.g., lights left on)?

3. Ask students: Should you replace a battery as soon as it is past the warranty?

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Safety related to battery (acid, electricity)
3. Specific Gravity	3. Specific gravity—ratio of weight of given amount of liquid to weight of equal amount of water The higher the specific gravity, the more fully the battery is charged.
4. Hydrometer	4. Has floats that measure density of electrolyte. If battery water is low, add water and charge battery before conducting hydrometer test. Readings taken at 80°F (see chart)
5. Built-in Hydrometer	5. Not trustworthy: • May stick in place • Reads only one cell (may have bad cell)

Specific Gravity	State of Charge	Battery Voltage
1.265	Fully Charged	12.6 or higher
1.225	75% Charged	12.4
1.190	50% Charged	12.2
1.155	25% Charged	12.0
Lower than 1.120	Discharged	11.9 or lower

Presentation Outline	Steps to Cover/Key Points to Make
6. Digital Multimeter or Digital Voltmeter	6. Take reading from each cell. Should read 2.1 volts per cell fully charged.
7. Maintenance-Free Battery	7. If it has sealed cells, cannot use hydrometer to test battery. Use digital multimeter. If battery has recently been charged, turn headlights on for 1 minute to remove surface charge. (See chart in Step 3 for corresponding state of charge).
8. Determining Needed Service	8. Using diagnostic information gathered, refer to service manuals to identify needed service. If hydrometer specific gravity or total battery voltage is low, charge battery and retest. Do not attempt to charge a frozen battery. Methods for determining whether battery is fully charged: ◆ Specific gravity holds at 12.65 or higher ◆ Digital multimeter indicates 12.68 volts or higher ◆ Ammeter on charger has fallen to 3 amps or less

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

The applied science teacher could help students in defining and determining specific gravity and understanding how batteries convert chemical energy to electricity and soak up voltage spikes from electrical systems.

Review:

Ask students review questions such as the following:

1. Why do you take readings between cells?
2. How do you test a maintenance-free battery? How is this different from testing other batteries?

Application:

1. Give students a number of sets of readings, and have them determine the appropriate service for battery.
2. Give students a number of batteries, and have them determine their state of charge using (a) a digital multimeter and (b) a hydrometer.

Evaluation:

√ Each student will perform a battery state-of-charge test and determine needed service. His/her performance will be evaluated using a copy of the performance checklist for Competency 6.2.1.

Competency 6.2.1: Perform battery state-of-charge test; determine needed service

Performance Checklist

In performing a battery state-of-charge test and determining needed service, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Selected appropriate method for testing battery state of charge (e.g., specific gravity or open circuit voltage test)	☐	☐	☐	☐	☐
5. Analyzed test results	☐	☐	☐	☐	☐
6. Determined needed service	☐	☐	☐	☐	☐
7. Serviced battery in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name______________________________**Date**______________

Competency 6.2.2: Perform battery capacity (load, high-rate discharge) test; determine needed service

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Perform a battery capacity test, and determine needed service
Criteria:	In accordance with the criteria in the checklist for Competency 6.2.2

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when performing battery capacity tests and determining needed service. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Ask students whether a battery state-of-charge test will indicate how long a battery will stay charged.

2. Ask students which of the three measured electrical properties—volts, amps, or ohms—would be the one which would tell the actual condition of the battery.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Performing a battery capacity test really puts a strain on the battery. If this test is not properly performed, the battery can blow up in your face.
3. Digital Voltmeter or Multimeter	3. Use digital voltmeter or multimeter to take readings to determine state of charge (see chart in 6.2.1).
4. Cold Cranking Amps	4. Rating of amount of amps the battery can supply at 0 degrees for 30 seconds
5. Using Hand-Held Load Tester	5. Hook positive to positive. Hook negative to negative. Hook inductive clamp to positive cable.
6. Testing Battery	6. Battery should be fully charged. Carbon pile is used to load the battery. Load for 15 seconds at one-half the CCA rating. Voltage at end of test (while under load) should not go under 9.6 volts.
7. Determining Needed Service	7. Using diagnostic information gathered, refer to service manuals to identify needed service.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

The applied science teacher could provide information on the relation of temperature to battery performance.

Review:

Ask students review questions such as the following:

1. When testing the battery, should the battery be fully charged or fully discharged?
2. Define *cold cranking amps.*

Application:

1. Give students a faulty battery and a set of readings, and have them determine the condition of the battery and what should be done next: (a) replace the battery or (b) charge and retest the battery.
2. Give students a set of batteries, and have them perform battery capacity tests and determine the condition of the batteries.

Evaluation:

√ Each student will perform a battery capacity test and determine needed service. His/her performance will be evaluated using a copy of the performance checklist for Competency 6.2.2.

Competency 6.2.2: Perform battery capacity (load, high-rate discharge) test; determine needed service

Performance Checklist

In performing a battery capacity test and determining needed service, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Accurately determined test load amperage	☐	☐	☐	☐	☐
5. Performed load/high-rated discharge test using appropriate test equipment	☐	☐	☐	☐	☐
6. Analyzed test results	☐	☐	☐	☐	☐
7. Determined needed service	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 6: Electrical/Electronic Systems

Subunit 6.2: Battery Diagnosis and Service

Competency 6.2.6: Inspect and clean battery cables, connectors, clamps, and hold-downs; repair or replace as needed

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Inspect and clean battery cables, connectors, clamps, and hold-downs; and repair or replace them as needed
Criteria:	In accordance with the criteria in the checklist for Competency 6.2.6

Introduction:

General Introductory Techniques: Share personal experiences you have had when inspecting, cleaning, and repairing/replacing battery cables, connectors, clamps, and hold-downs in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Ask students whether they have ever had a car that would not start due to a dirty battery or corroded battery posts.
2. Something as simple as dirt on top of a battery can cause the battery to drain overnight and leave you with a non-starting car.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Safety related to battery (e.g., acid, electricity) and terminal cleaner
3. Inspecting Battery	3. Procedures for inspecting each of the following: • Terminals (corrosion, looseness) • Connectors (damage, corrosion) • Battery hold-down (rust, looseness) Criteria for determining need to clean, repair, or replace components
4. Cleaning Terminals	4. Clean side terminals with baking soda/water mixture. Clean tapered posts and mating surfaces of cable clamps with special cleaning brush. Clean battery cover with a scraper and wire brush.
5. Tightening Battery Hold-Down	5. Tighten securely: • If too tight, case may crack. • If too loose, plates may vibrate.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher can discuss causes of corrosion (chemical reactions taking place) and the use of Ohm's law to determine the resistance of a loose terminal.

Review:

Ask students review questions such as the following:

1. What mixture should be used to clean terminal ends?
2. What tools work best in cleaning the terminal ends?
3. What are the colors of corroded battery terminals?

Application:

1. Have students practice inspecting and cleaning batteries.
2. Have students use a digital multimeter to check voltage drop across (a) a tight terminal, (b) a loose terminal, (c) a corroded terminal, and (d) a clean terminal.

Evaluation:

√ Each student will inspect and clean battery cables, connectors, clamps, and hold-downs and repair or replace them as needed. His/her performance will be evaluated using a copy of the performance checklist for Competency 6.2.6.

Competency 6.2.6: Inspect and clean battery cables, connectors, clamps, and hold-downs; repair or replace as needed

Performance Checklist

In inspecting and cleaning battery components and repairing or replacing them as needed, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Visually inspected each of the following battery components in accordance with established procedures:					
a. Cables	☐	☐	☐	☐	☐
b. Post	☐	☐	☐	☐	☐
c. Connectors	☐	☐	☐	☐	☐
d. Hold-down	☐	☐	☐	☐	☐
5. Removed battery cables in accordance with recommended procedure	☐	☐	☐	☐	☐
6. Identified servicing (cleaning, repair, replacement) needed	☐	☐	☐	☐	☐
7. Serviced battery in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
8. Performed complete final visual inspection	☐	☐	☐	☐	☐
9. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name______________________________________**Date**______________

Unit 6: Electrical/Electronic Systems

Subunit 6.2: Battery Diagnosis and Service

Competency 6.2.7: Start a vehicle using jumper cables and a battery or auxiliary power supply

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Start a vehicle using jumper cables and a battery or auxiliary power supply
Criteria:	In accordance with the criteria in the checklist for Competency 6.2.7

Introduction:

General Introductory Techniques: Share personal experiences you have had when starting a vehicle using jumper cables and a battery or auxiliary power supply in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Have you ever jump-started a vehicle? What procedure did you use?

2. What safety precautions did you follow? Did you know that the incorrect use of jumper cables can cause a battery to blow up?

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Safety related to computer (don't use more than 16 volts) Danger of explosion: ◆ Hydrogen and oxygen are generated within cells during normal operation. ◆ A spark can set off an explosion of these gases. ◆ Face/eye protection is critical. ◆ Make sure battery is not frozen.
3. Jumper Cables	3. Be sure they are in good condition and copper-stranded.
4. Connecting Jumper Cables	4. General connection sequence: ◆ Connect to positive battery terminal on starting car. ◆ Connect to positive battery terminal on stalled car. ◆ Connect to negative battery terminal on starting car. ◆ Connect to ground on engine (away from battery) in stalled car. For alternate connection locations, check service manual.
5. Disconnecting Jumper Cables	5. Disconnect cables in reverse order from the connecting sequence.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

The applied science teacher could work with students on why the hydrogen and oxygen in a battery are a potentially explosive combination.

Review:

Ask students review questions such as the following:

1. Why should you worry about sparks when jump-starting a car?
2. Why is the last connection made to ground instead of the negative terminal?
3. How can the use of jumper cables cause a battery to blow up?
4. What kind of damage can be caused if the jumper leads are reversed?

Application:

1. Give students a diagram of a good battery and a diagram of a battery in a stalled car, and have them indicate how the jumper cables should be connected.

Evaluation:

√ Each student will start a vehicle using jumper cables and a battery or auxiliary power supply. His/her performance will be evaluated using a copy of the performance checklist for Competency 6.2.7.

Competency 6.2.7: Start a vehicle using jumper cables and a battery or auxiliary power supply

Performance Checklist

In starting a vehicle using jumper cables and a battery or auxiliary power supply, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Ensured that jumper cables were in good, safe condition	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Performed complete visual inspection	☐	☐	☐	☐	☐
5. Connected jumper cables from vehicle to battery or auxiliary power supply in proper sequence	☐	☐	☐	☐	☐
6. Started vehicle	☐	☐	☐	☐	☐
7. Disconnected jumper cables in proper sequence	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name_______________________________________**Date**______________

Competency 6.3.1: Perform starter current draw and circuit voltage drop test; determine needed repairs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Perform a starter current draw and circuit voltage drop test, and determine needed repairs
Criteria:	In accordance with the criteria in the checklist for Competency 6.3.1

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when performing starter current draw and circuit voltage drop tests and determining needed repairs. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. How can you determine whether the starter is bad?
2. What other problems can cause a nonstarting problem?

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Checking Battery	2. Check battery voltage (6.2.1). Load-test battery (6.2.2). Check battery terminal and cables (6.2.6).
3. Testing Current Draw	3. Disable ignition system. Hook positive to positive. Hook negative to negative. Hook inductive clamp to positive cable. Crank engine for 15 seconds. Read amount of amp draw. Compare to manufacturer's specifications. General rules of thumb: ◆ 4- or 6-cylinders..........150 amp max ◆ V-8 (except GM).........200 amp max ◆ GM V-8.......................250 amp max

Presentation Outline	Steps to Cover/Key Points to Make
4. Testing Voltage Drop	4. Disable ignition system. Hook voltmeter across cable, switch, or circuit to be tested. Energize starter. Compare readings. If readings exceed 0.05 volts, check for high resistance at cable connections. Clean or tighten connections. Replace cable if necessary.
5. Excessive Current Draw	5. Possible causes: ◆ Worn bushings ◆ Worn brushes ◆ Oil that is too thick ◆ Shorted or grounded starter windings ◆ Tight or seized engine ◆ High resistance in cables or connectors

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

Throughout Unit 6, the applied science teacher could work with students on basic principles of electricity (volts, amps, ohms, watts, etc.), and the applied mathematics teacher could help students in solving problems using Ohm's law.

Review:

Ask students review questions such as the following:

1. Why is it important for the connections to be clean and tight? What could happen if they are not?
2. What kinds of problems would cause high current draw?
3. Why is so important to wear safety glasses when performing these tests?

Application:

1. Have students diagram all connections and parts of a starting system.
2. Give students a written case study describing a faulty starting system and all its associated readings, and have them determine the cause of the starting system failure.
3. Have students practice reading voltage drops on the wiring and components of a given starter system.
4. Have students practice testing current draw on a given starter system.

Evaluation:

√ Each student will perform a starter current draw and circuit voltage drop test and determine needed repairs. His/her performance will be evaluated using a copy of the performance checklist for Competency 6.3.1.

Competency 6.3.1: Perform starter current draw and circuit voltage drop test; determine needed repairs

Performance Checklist

In performing a starter current draw and circuit voltage drop test and determining needed repairs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Inspected battery and electrical connections	☐	☐	☐	☐	☐
5. Tested current draw in accordance with standard procedure	☐	☐	☐	☐	☐
6. Checked current draw against manufacturer's specification	☐	☐	☐	☐	☐
7. Checked voltage drop on starter circuit	☐	☐	☐	☐	☐
8. Determined needed repair(s)	☐	☐	☐	☐	☐
9. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competency 6.4.1: Diagnose charging system problems that cause an undercharge, a no-charge, or an overcharge condition

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Diagnose charging system problems that cause an undercharge, a no-charge, or an overcharge condition
Criteria:	In accordance with the criteria in the checklist for Competency 6.4.1

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when diagnosing charging system problems that cause an undercharge, a no-charge, or an overcharge condition. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Ask students if they've ever stopped the car, gone off for a short time, and come back to find the car won't start. Most likely this was a charging system problem. When this happens, you need to be able to find the faulty part.

2. Before charging system diagnosis and repair, you first need to make sure the battery is okay. How do you do this?

3. Ask students if they know the difference between AC and DC voltage.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Safety related to battery (acid, electricity) and battery terminal cleaner
3. Inspections	3. Visually check the following: ◆ Battery ◆ Terminals ◆ Connections ◆ Belts Check whether charging indicator light is operational.
4. Using Starting/Charging System Analyzer	4. Connect leads following manufacturer's specifications (each one has different diagnosis procedures). Diagnosis procedure, including— ◆ Turn key on. ◆ Read amp draw (2-8 amps). ◆ Run engine at 2,000 RPM. ◆ Load system to reach highest amp reading. ◆ Total amps should be within 10% (or 15 amps) of rated output.

Presentation Outline	Steps to Cover/Key Points to Make
5. If Test Fails	5. Bypass regulator following manufacturer's specifications. Inspect alternator circuit external to alternator. If all circuits are working correctly and alternator does not pass test, need to replace alternator.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could work with students on the theory of electromagnetic induction and the three determinants in increasing or decreasing the production of electricity: size of magnet, size or number of conductor loops, and speed or angle of magnet or conductor loops.

Review:

Ask students review questions such as the following:

1. Should the battery be charged before the test?
2. Why is it important to check the belts?
3. You have checked the connections and found them to be tight. What else should you check regarding the connections?

Application:

1. Provide students with a vehicle with a ***good*** charging system, and have them practice using the charging system test equipment on that system.
2. Provide students with a vehicle with a ***defective*** charging system, and have them practice using the charging system test equipment on that system.
3. Give students a list of readings from a charging system for a particular manufacturer, and have them identify likely problems in that system.

Evaluation:

√ Each student will diagnose charging system problems that cause an undercharge, a no-charge, or an overcharge condition. His/her performance will be evaluated using a copy of the performance checklist for Competency 6.4.1.

Competency 6.4.1: Diagnose charging system problems that cause an undercharge, a no-charge, or an overcharge condition

Performance Checklist

In diagnosing charging system problems, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Visually inspected belts, connections, battery, and charging indicator in accordance with manufacturer's procedures	☐	☐	☐	☐	☐
5. Connected starting/charging system analyzer leads in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
6. Tested charging system in accordance with standard procedure	☐	☐	☐	☐	☐
7. Analyzed test results	☐	☐	☐	☐	☐
8. Accurately diagnosed cause of problem (circuit problem, alternator)	☐	☐	☐	☐	☐
9. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competency 6.4.2: Inspect and adjust alternator drive belts; replace as needed

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Inspect and adjust an alternator drive belt, and replace it as needed
Criteria:	In accordance with the criteria in the checklist for Competency 6.4.2

Introduction:

General Introductory Techniques: Share personal experiences you have had when inspecting, adjusting, and replacing alternator drive belts in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Ask students: How can you determine whether an alternator belt is adjusted properly?
2. Ask students: How will age affect a belt? What kinds of problems can a loose belt cause?
3. Show students an engine mock-up with a serpentine belt removed, and ask for a volunteer to try to mount the belt (it's simple, but the mounting route is not obvious). Let the rest of the class offer suggestions as the volunteer works.
4. When a customer indicates that he or she has heard a belt noise, one of your first steps should be to make sure it is actually a belt that is making the noise.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Importance of having engine off and key out of ignition Safety related to moving parts
3. Checking V Belts	3. Check tension every 6 months or 12,000 miles. Check tension in the middle of the pulleys. Check condition of belts (cracks, wear).
4. Checking Serpentine Belts	4. Serpentine belts not only drive the alternator but also drive other power units such as water pumps, air pumps, and power steering pumps. Check for cracks parallel to the ribbed side. Cracks generally indicate a defective belt. ***Note:*** Some manufacturer's specify that minor cracks are okay as these are due to reverse binding of the belt. Importance of pulley alignment Procedure for removing and installing a serpentine belt

Presentation Outline	Steps to Cover/Key Points to Make
5. Checking Belt Tension	5. Procedure for using belt tension gauge General rules of thumb: • If free span between pulleys is less than 12", deflection should be 1/8" to 1/4". • If free span between pulleys is more than 12", deflection should be 1/8" to 3/8".
6. Adjusting Belt	6. Adjust as necessary according to manufacturer's specifications. Typical adjustment procedure
7. Replacing Belt	7. Replace in accordance with manufacturer's specifications. Typical replacement procedure

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could work with students on reading both metric and American rulers to fractions of an inch (a skill needed in using the belt tension gauge).

Review:

Ask students review questions such as the following:

1. What three things should you check on a belt?
2. Why is it important to have the key out of the ignition when checking belt tension?
3. What procedure should be followed in checking the tension of a V belt?
4. What should you look for in trying to determine whether a serpentine belt is defective?

Application:

1. Provide students with worksheets showing the fronts of several engines that use serpentine belts, and have them diagram how the belt should be mounted, using appropriate shop manuals to assist them in their work.
2. Provide students with several belts, and have them describe the condition of each.
3. Set up several engines with belts on them, and have students check the tension on each belt.
4. Provide students with assorted engines with V and serpentine belts, and have them practice removing and installing the belts.

Evaluation:

√ Each student will inspect and adjust an alternator drive belt and replace it as needed. His/her performance will be evaluated using a copy of the performance checklist for Competency 6.4.2.

Competency 6.4.2: Inspect and adjust alternator drive belts; replace as needed

Performance Checklist

In inspecting and adjusting an alternator drive belt and replacing it as needed, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Visually inspected drive belts in accordance with standard procedures	☐	☐	☐	☐	☐
5. Determined belt tension using gauge or rule of thumb	☐	☐	☐	☐	☐
6. Identified whether belt needed to be adjusted or replaced	☐	☐	☐	☐	☐
7. Adjusted or replaced belt in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name_______________________________________**Date**______________

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"Heating and Air
Conditioning"
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Units 1/7/8: Engine Repair/Heating and Air Conditioning/Engine Performance

Subunits 1.4/7.4./8.11: Lubrication and Cooling Systems Diagnosis and Repair/ Heating and Engine Cooling Systems Diagnosis and Repair/ Engine Related Service

Competency 1.4.3	Perform cooling system tests (pressure, combustion, leakage, and temperature); determine needed repairs
Competency 7.4.2	Perform cooling system, cap, and recovery system tests (pressure, combustion, leakage, and temperature); determine needed repairs
Competency 8.11.3	Verify engine operating temperature; determine needed action
Competency 8.11.4:	Perform cooling system pressure tests; check coolant condition; inspect and test radiator, pressure cap, coolant recovery tank, and hoses; service or replace as needed

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Perform cooling system tests, and determine needed repairs
Criteria:	In accordance with the criteria in the checklist for Competencies 1.4.3/7.4.2/ 8.11.3/8.11.4

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when performing cooling system tests and determining needed repairs. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. A cooling system is very important to engine performance and to the engine's service life.
2. Without proper cooling, an engine can suffer severe damage in just a manner of minutes.
3. Antifreeze is important in warm weather as well as cold. In warm weather, it provides improved cooling.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Be always aware of moving parts (e.g., fan blades, pulleys, belts). Radiator coolant is under pressure in a running engine, and it is ***hot***. If you try to take off the radiator cap while the engine is hot, the release of pressurized liquid can make the coolant boil and expand. If allowed to spurt out of the radiator filler neck area, boiling coolant can cause ***severe burns***.
3. System Components	3. Characteristics/operation of the following: ◆ Radiator ◆ Thermostat ◆ Heater core ◆ Hoses ◆ Pump ◆ Radiator pressure cap Examples of worn components Problems that might occur as a result of the wear

Presentation Outline	Steps to Cover/Key Points to Make
4. Performing Pressure Test	4. This test is used to quickly locate the source of coolant leakages. The *pressure tester* is a hand-operated air pump, which forces compressed air onto the coolant. General procedure: • Remove radiator pressure cap (with car at normal operating temperature). • Check coolant level. • Use antifreeze hydrometer to test freeze protection level of coolant. • Wipe inside of filler neck; check for damage inside sealing seat. • Inspect overflow tube for dents, kinks, or obstructions. • Inspect cams on outside of filler neck; reform any bent cams. • Install the tester on the radiator filler neck, in place of the radiator cap. • Using manufacturer's specifications, pump the tester until the gauge on the tester reaches the correct pressure (generally in the 14–16 psi or 96 kPa range). ***Caution:*** Do not over-pressurize the system beyond the specifications because you could cause a component to rupture. The gauge pressure should hold for at least 3 minutes steady. Document any drop of pressure seen. Interpret reading: • If pressure holds • If pressure drops quickly • If pressure drops slowly Visually inspect all parts (hose fittings, clamps, radiator, water pump, intake manifold, cylinder head-to-block contacts, core plugs, heater core, etc.) for coolant leakage.

Presentation Outline	Steps to Cover/Key Points to Make
5. Performing Combustion Leak Test	5. This test is used to check for the presence of combustion chamber gases in the coolant. It should be performed when you have signs that point to a blown head gasket, cracked block, or cracked cylinder head (e.g., overheating, bubbles in coolant, a rise in coolant level when starting the engine). Put the *combustion leak tester* onto the radiator filler neck. Run the engine; then squeeze the tester bulb and release. This draws air through the test fluid. The test fluid (usually blue) will change to a yellow color if any combustion gases are leaking into the engine coolant. If the fluid stays blue, there is no combustion leak into the coolant. If a leak is indicated, short out the cylinders one at a time (***no longer than 15 seconds*** so as not to damage the catalytic converter). When the fluid does not change its color, you have found your leaking cylinder(s). Another method is to use an exhaust gas analyzer
6. Alternative Method for Performing Combustion Leak Test	6. This method uses an exhaust gas analyzer. Remove the radiator cap, and place a tail pipe probe over the neck. Accelerate the engine, and watch the hydrocarbon (HC) meter. If the meter reads, you have a leak.
7. Engine Overheating	7. Average operating temperature of an engine (around 230°) Importance of maintaining normal operating temperature in terms of engine operation and emissions Reasons why an engine may overheat

Presentation Outline	Steps to Cover/Key Points to Make
8. Performing Temperature Test	8. Remove radiator cap, and insert coolant thermometer into the neck. Run engine for up to 10 minutes, and note temperature while looking for coolant flow through radiator tubes. Temperature should be approximately 10%–15% above the thermostat rating of the engine. If the temperature is too high, locate causes of excess heat: • Feel upper radiator hose, checking for excessive temperature and/or gurgling. • Check coolant recovery tank for proper level. If the temperature is too low, suspect open thermostat, locked fan clutch, or electric fan running constantly.
9. Alternative Method for Performing Temperature Test	9. Tempsticks give a quick and fairly accurate diagnosis of thermostat operation without having to remove it. They are made of wax, one melting at about 188°F, the other at about 202°F. First, draw a short line on the thermostat housing with the 188° stick (one color). Using the 202° stick (which is another color), draw another line parallel to the 188° line and about 1/2" away. As the thermostat begins to open, the 188° line should melt. As the engine reaches operating temperature (thermostat fully open), the 202° line should melt.
10. Determining Needed Repairs	10. Using diagnostic information gathered, refer to service manuals to identify needed repairs.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could cover the composition of antifreeze, hazards related to handling antifreeze, and how coolant operates at different temperatures (230°F and 212°F).

Review:

Ask students review questions such as the following:

1. Describe safety concerns that apply to servicing/diagnosing the cooling system.
2. If you over-pressurize the radiator and cooling system during a pressure test, what could be the consequence?
3. When you hear the expression, "the engine's normal operating temperature," what range do you think that means?
4. What types of damage could occur as a result of an overheating engine?
5. What effect does one pound of pressure have on the boiling point of coolant?
6. True or False: The proper proportion of antifreeze to water is 20:40.

Application:

1. Give students a diagram of a cooling system, and have them indicate the potential trouble spots.
2. Have students use the textbook and service manuals to identify and define cooling system vocabulary terms. This can be done on an individual or small-group basis.
3. Give students a written case study describing a specific overheating problem, and have them troubleshoot that problem.
4. As students practice pressure testing the coolant system, quiz them individually on the process (e.g., ask them to explain how to locate leaks).
5. Create leaks in a coolant system (e.g., by loosening the clamps), and have students use the appropriate checks and tests to locate the problem.

Evaluation:

√ Each student will perform cooling system tests and determine needed repairs. His/her performance will be evaluated using a copy of the performance checklist for Competencies 1.4.3/7.4.2/8.11.3/8.11.4.

Competency 1.4.3	Perform cooling system tests (pressure, combustion, leakage, and temperature); determine needed repairs
Competency 7.4.2	Perform cooling system, cap, and recovery system tests (pressure, combustion, leakage, and temperature); determine needed repairs
Competency 8.11.3	Verify engine operating temperature; determine needed action
Competency 8.11.4:	Perform cooling system pressure tests; check coolant condition; inspect and test radiator, pressure cap, coolant recovery tank, and hoses; service or replace as needed

Performance Checklist

In performing cooling system tests and determining needed repairs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Selected appropriate equipment for performing cooling system pressure test	☐	☐	☐	☐	☐
5. Performed cooling system pressure test in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
6. Determined needed repairs	☐	☐	☐	☐	☐
7. Selected appropriate equipment for performing cooling system combustion leakage test	☐	☐	☐	☐	☐
8. Performed cooling system combustion leakage test in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
9. Determined needed repairs	☐	☐	☐	☐	☐
10. Selected appropriate equipment for performing cooling system temperature test	☐	☐	☐	☐	☐
11. Performed cooling system temperature tests in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
12. Determined needed repairs	☐	☐	☐	☐	☐
13. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competency 7.4.3: Inspect engine cooling and heater system hoses and belts; replace as needed

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Inspect engine cooling and heater system hoses and belts, and replace them as needed
Criteria:	In accordance with the criteria in the checklist for Competency 7.4.3

Introduction:

General Introductory Techniques: Share personal experiences you have had when inspecting and replacing engine cooling and heater system hoses and belts in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Ask students to describe what hoses and belts do, and why such simple things are so important.

2. Display several hoses, and ask students whether each belt is good or bad. Have them justify their opinions. Indicate that by the end of the lesson, all students should be able to correctly determine the condition of belts and hoses.

References:

Technical service bulletins (TSBs); *NAPA Belt & Hose Guide* #1, #2, and #3. (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safety & Vehicle Care Practices	2. Cautions regarding coolant temperature and pressure in the cooling system Cautions regarding moving parts Exhaust removal system requirements Importance of protecting vehicle's painted surfaces from damage by coolant
3. Inspecting Hoses	3. Visually check hoses for signs of damage or malfunction: • Softness • Swelling • Leaks • Cracks • Oil contamination • Loose connections • Excessive hardness • Excessive brittleness Tighten any loose hose clamps found. Clean any corrosion found under hose where it attaches to engine, radiator, or heater core. Determine replacement needed.

Presentation Outline	Steps to Cover/Key Points to Make
4. Pressure-Testing Cooling System	4. Remove radiator cap, making sure that coolant is not sprayed on bystanders or vehicle. Place cooling system pressure tester on radiator neck, and pump pressure up to manufacturer's specifications. If cooling system holds pressure for several minutes, a leak is usually not indicated. If cooling system pressure leaks down, check for leaks (check all hoses and under dash where heater hoses go into the heater core). In some cases (e.g., leaking head gasket), the leak may not be visible. Determine replacement needed.
5. Checking Belts	5. Types of belts: V and serpentine Visually check belts for signs of damage or malfunction: ◆ Cracks ◆ Cuts ◆ Oil or coolant contamination ◆ Dry rot ◆ Glazing ◆ Wear Listen to belts for squealing or growling noises. Check for proper tension (less than 1/2" movement up or down), excessive play, abnormal noises. Check brackets and pulleys. Check belt pulleys for alignment and physical damage (particularly with serpentine belts). Determine whether belts and pulleys need to be lubricated or replaced.
6. Replacing Hoses and Belts	6. Replace hoses and belts in accordance with manufacturer's specifications.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could discuss what happens when water freezes in an enclosed space like an engine block; how adding antifreeze and pressure affects the freezing and boiling points of water; and heat transfer principles (how to remove excess heat using air, a liquid, and fans).

Review:

Ask students review questions such as the following:

1. What types of conditions should you watch for when checking coolant system hoses?
2. What types of conditions should you watch for when checking coolant system belts?
3. Why is it important to use the exact hose or belt specified by the manufacturer?
4. If a customer told you that his or her vehicle was making a squealing noise, what might be the problem?

Application:

1. Give students ten different worn belts to examine, and have them describe in writing the condition of each.
2. Provide students with a teacher-prepared inspection checklist, and have them use this in performing inspections of cooling system hoses and belts.
3. As students practice inspecting engine cooling and heater system hoses and belts, quiz them individually on the process (e.g., ask them to explain functions of the heater and cooling belts and hoses).

Evaluation:

√ Each student will inspect engine cooling and heater system hoses and belts and replace them as needed. His/her performance will be evaluated using a copy of the performance checklist for Competency 7.4.3.

Competency 7.4.3: Inspect engine cooling and heater system hoses and belts; replace as needed

Performance Checklist

In inspecting engine cooling and heater system hoses and belts and replacing them as needed, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Pressure-tested cooling system in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
5. Visually inspected hoses and clamps for tightness and damage	☐	☐	☐	☐	☐
6. Visually inspected belts for tightness and damage	☐	☐	☐	☐	☐
7. Determined servicing needed	☐	☐	☐	☐	☐
8. Replaced hoses and belts in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
9. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name______________________________________**Date**______________

Units 7/8: Heating and Air Conditioning/Engine Performance

Subunits 7.4/8.11: Heating and Engine Cooling Systems Diagnosis and Repair/ Engine Related Service

Competencies 7.4.4/8.11.5: Inspect and test thermostat, by-pass, and housing; replace as needed

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Inspect and test thermostat, by-pass, and housing; and replace them as needed
Criteria:	In accordance with the criteria in the checklist for Competencies 7.4.4/8.11.5

Introduction:

General Introductory Techniques: Share personal experiences you have had when inspecting, testing, and replacing thermostats, by-passes, and housings in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. The thermostat rating recommended by most of today's manufacturer's is 195°.
2. Discuss how engine temperature is controlled.
3. Explain how the operation of the thermostat affects fuel economy.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Cautions regarding coolant temperature and pressure in cooling system Cautions regarding moving parts Exhaust removal system requirements
3. By-pass	3. Characteristics—usually a rubber hose attached between the water pump and engine block Purpose—provides for coolant flow through engine prior to thermostat opening Operation—allows coolant to flow between water pump and engine ***Note:*** Some engines have thermostats with a by-pass valve that shuts off the engine by-pass after warm-up so that all coolant is forced to flow into radiator.
4. Thermostat	4. Characteristics—starts to open within 3° of specified temperature; may have a subvalve and a main valve to help prevent hot spots at high temperatures Purpose—regulates engine temperature Operation—closed when engine is cold; opens when engine warms up Installation procedure (ensure that temperature pellet or side is installed toward the engine).

Presentation Outline	Steps to Cover/Key Points to Make
5. Testing Thermostat	5. Method 1 (with thermostat on vehicle): • Vehicle engine must be cool when radiator cap is removed. • Be sure vent tube is in vehicle exhaust. • Run car to combustion temperature before performing test. • Insert thermostat into coolant. • If thermostat is operating properly, coolant will flow steadily inside the radiator, and temperature will not rise above temperature specified by manufacturer. Method 2 (off-car procedure): • Heat a solution of antifreeze and water until the thermostat begins to open. • Check the temperature of the solution. • Compare actual temperature to temperature rating of the thermostat. Determine needed repairs.
6. Inspecting Housing	6. Inspect the housing for the following: • Warpage • Cracks • Damage to sealing surface
7. Replacing Thermostat and Housing	7. Follow manufacturer's specifications. Be sure to check housing for damage when removing gasket. Replace coolant. Pressure-test system for leaks once new thermostat is in place and housing is reinstalled. Check thermostat for proper operation.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could discuss what happens when water freezes in an enclosed space like an engine block; how adding antifreeze and pressure affects the freezing and boiling points of water; and heat transfer principles (how to remove excess heat using air, a liquid, and fans).

Review:

Ask students review questions such as the following:

1. How can you determine whether the thermostat is installed correctly?
2. Why does the thermostat in the coolant system open and close?
3. What does the thermostat measure?
4. True or False: The thermostat is not needed and can be removed in warm weather.

Application:

1. Give students a teacher-prepared diagram of an engine cooling system, and have them diagram the flow of coolant twice (perhaps using different colors): once with the thermostat open, and once with the thermostat closed.
2. Provide students with a heater, a solution of antifreeze and water, a thermometer or pyrometer, and a thermostat, and have them heat the solution and note the temperature at two points: (a) when the thermostat begins to open, and (b) when the thermostat is fully open.
3. As students practice inspecting and testing the thermostat, by-pass, and housing, quiz them individually on the process (e.g., ask them to explain how to properly test the thermostat rating).

Evaluation:

√ Each student will inspect and test a thermostat, by-pass, and housing and replace them as needed. His/her performance will be evaluated using a copy of the performance checklist for Competencies 7.4.4/8.11.5.

Competencies 7.4.4/8.11.5: Inspect and test thermostat, by-pass, and housing; replace as needed

Performance Checklist

In inspecting and testing a thermostat, by-pass, and housing and replacing as needed, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Performed the following tests/checks in accordance with manufacturer's specifications:					
a. Cooling system pressure test	☐	☐	☐	☐	☐
b. Visual inspection of by-pass and housing	☐	☐	☐	☐	☐
c. Coolant temperature check	☐	☐	☐	☐	☐
5. Removed thermostat/housing in accordance with standard procedure	☐	☐	☐	☐	☐
6. Determined servicing or repair needed	☐	☐	☐	☐	☐
7. Reinstalled or replaced thermostat/housing in accordance with standard procedure	☐	☐	☐	☐	☐
8. Pressure-tested system for leaks	☐	☐	☐	☐	☐
9. Checked thermostat for proper operation	☐	☐	☐	☐	☐
10. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____Date_______________

Competency 7.4.5: Determine coolant condition; drain and recover

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Determine coolant condition, and drain and recover the coolant
Criteria:	In accordance with the criteria in the checklist for Competency 7.4.5

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when determining coolant condition and draining and recovering coolant. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Coolant is considered a hazardous material and requires special handling. Recycling coolant results in less waste. Some shops do bulk recycling, while others prefer to recycle coolant car by car.
2. Define *coolant status*, and explain how coolant status is determined.
3. Ask students if they know about the new types of antifreeze several auto manufacturers have.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Cautions regarding coolant temperature and pressure in cooling system Cautions regarding moving parts Exhaust removal system requirements Dangers associated with antifreeze (fatal if swallowed)
3. Checking Coolant	3. Typical antifreeze colors: phosphorescent green, orange, strawberry red Perform visual check of antifreeze, looking for— ◆ Dirt ◆ Oils ◆ Foam ◆ Solid color (not streaky) Check antifreeze for correct temperature rating or freeze point: ◆ For regular "green" antifreeze, a specific gravity tester is generally used. ◆ For long-life antifreeze (e.g., DEX-COOL®), a refractometer is recommended.

Presentation Outline	Steps to Cover/Key Points to Make
	Check acid level of antifreeze: • Check with pH strips or voltmeter. • Connect one end of voltmeter to ground and the other into the coolant. • Voltmeter should read less than 1 volt. If over 1 volt, the antifreeze is too acidic.
4. Draining Coolant	4. Standard procedures: • Make sure engine is cool. • Remove radiator cap. • Locate drain valve on radiator. • Place clean drain pan under valve. • Open valve full and let all coolant drain from radiator. • Close valve.
5. Recovering Coolant	5. Environmental concerns EPA, state, and local guidelines (e.g., discharge in small amounts may be permissible by municipal permit) Bulk recovery: • Coolant must be safely stored on-site for pickup by recycler. On-site recycling: • Hook coolant recycling machine to vehicle heater hoses in accordance with machine manufacturer's specifications.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could work with students on specific gravity, pH level (acidity-alkalinity), environmental safety, and refraction of light (in relation to measuring coolant freeze point).

Review:

Ask students review questions such as the following:

1. Why is it important to follow EPA guidelines when storing or discarding coolant supplies?
2. What are some common contaminants found in coolant systems?
3. Why are coolants maintained at different minimum temperatures in different states?
4. If a customer told you that his or her vehicle had boiled over, what would you do to protect the vehicle's engine from freezing temperatures in the upcoming winter months?

Application:

1. Have students identify the guidelines for antifreeze handling in their home community. Students could also prepare fliers, handouts, or posters to communicate those guidelines to others.
2. Have students determine the acidity of the antifreeze in a given car using a DMM and then make a recommendation concerning whether the antifreeze should be changed.
3. Have students determine the freeze point of coolant in a given car using a coolant freeze point tester and then indicate whether that freeze point is adequate for the locality in which the school is located.

Evaluation:

√ Each student will determine coolant condition and drain and recover the coolant. His/her performance will be evaluated using a copy of the performance checklist for Competency 7.4.5.

Competency 7.4.5: Determine coolant condition; drain and recover

Performance Checklist

In determining coolant condition and draining and recovering the coolant, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Visually inspected coolant for color and contaminants	☐	☐	☐	☐	☐
5. Accurately determined coolant freeze point	☐	☐	☐	☐	☐
6. Accurately determined coolant acidity level	☐	☐	☐	☐	☐
7. Identified all coolant problems	☐	☐	☐	☐	☐
8. Drained coolant according to standard procedure	☐	☐	☐	☐	☐
9. Recovered coolant in accordance with EPA requirements	☐	☐	☐	☐	☐
10. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 7: Heating and Air Conditioning

Subunit 7.4: Heating and Engine Cooling Systems Diagnosis and Repair

Competency 7.4.6: Flush system and refill with recommended coolant; bleed system

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Flush system, refill with recommended coolant, and bleed system
Criteria:	In accordance with the criteria in the checklist for Competency 7.4.6

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when flushing systems, refilling with recommended coolant, and bleeding system. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. There are several types of coolant on the market today. There is "traditional" antifreeze. In addition, there are coolants that provide environmental protection, some that last 5 years/150,000 miles, and some that are low in silicates.

2. Why is it necessary to flush the system before refilling with coolant?

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Dangers associated with antifreeze (fatal if swallowed; avoid splashing)
3. Flushing System	3. Purpose—to remove rust and scale Different types of cleaning solutions: • Heavy-duty—powdered phosphoric acid (residue is considered an environmental hazard) • Liquid—milder solution of phosphoric acid and detergent Procedure for routine system cleaning Procedure for radiator reverse flushing (forcing clear water and air backwards through system) EPA requirements

Presentation Outline	Steps to Cover/Key Points to Make
4. Selecting Antifreeze Solution	4. Types of antifreeze: • Traditional—fluorescent green; commonly used for years • Extended life: phosphate-free—recommended by some European OEMs (original equipment manufacturers) • Extended life: silicate-free—recommended by some Japanese OEMs • Propylene glycol—usually fluorescent green; more environmentally friendly than traditional ethylene glycol antifreeze • DEX-COOL®—5-year/150,000-mile antifreeze for most GM vehicles since 1996; orange for cars, strawberry red for trucks Check manufacturer's recommendations for the specific type to use.
5. Refilling System with Antifreeze	5. Follow manufacturer's specifications.
6. Bleeding System	6. Purpose for getting all air out of system Different procedures for bleeding system

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could provide information on the environmental benefits of propylene glycol–based antifreezes vs. ethylene glycol–based antifreezes and why a 50:50 antifreeze mix freezes at a lower temperature than a 100% antifreeze solution.

Review:

Ask students review questions such as the following:

1. Describe the different types of cleaning solutions.
2. What are important parts in cleaning?
3. What are the advantages and disadvantages associated with different types of cleaning solutions?
4. What are the advantages and disadvantages associated with different types of antifreeze?
5. Why can't you mix antifreeze types?

Application:

1. Have students develop a procedure sheet for bleeding a cooling system in a particular vehicle, using service manuals to assist them in their work.
2. Have students locate the material safety data sheets (MSDSs) and local guidelines for the flushing solutions used in the shop and then outline the proper procedure for disposing of each solution.
3. As students practice reverse flushing the cooling system in a particular car, quiz them individually on the process (e.g., ask them why it is important to use clear water).
4. As students practice removing coolant, refilling coolant, and bleeding the cooling system, quiz them individually on the process (e.g., ask them to explain the procedure they followed in determining which coolant to use).

Evaluation:

√ Each student will flush system, refill with recommended coolant, and bleed system. His/her performance will be evaluated using a copy of the performance checklist for Competency 7.4.6.

Competency 7.4.6: Flush system and refill with recommended coolant; bleed system

Performance Checklist

In flushing system, refilling with recommended coolant, and bleeding system, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Flushed cooling system using proper recovery system	☐	☐	☐	☐	☐
5. Ensured that system was fully flushed out	☐	☐	☐	☐	☐
6. Selected appropriate coolant for system	☐	☐	☐	☐	☐
7. Refilled cooling system in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
8. Bled cooling system in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
9. Performed final visual inspection	☐	☐	☐	☐	☐
10. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____ **Date**______________

Competency 7.8.1: Verify correct operation and maintenance of refrigerant handling equipment

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety and EPA guidelines
Behavior:	Verify correct operation and maintenance of refrigerant handling equipment
Criteria:	In accordance with the criteria in the checklist for Competency 7.8.1

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when verifying the correct operation and maintenance of refrigerant handling equipment. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Because the refrigerant used before 1994 (approximately) was destroying the ozone layer in the upper atmosphere, the Environmental Protection Agency (EPA) began to regulate the use of refrigerants for automobiles. One molecule of the old type of refrigerant can destroy 1,000,000 molecules of ozone.

2. Thus it is critical that the refrigerant handling equipment is handled by properly trained personnel who take great care that no refrigerant is released into the atmosphere.

References:

Technical service bulletins (TSBs); information from the Environmental Protection Agency (EPA) Website: www.epa.gov/ozone/title6/snap. (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Dangers associated with refrigerants: ◆ Can blind you (causes a permanent clouding of the eye) ◆ Can cause frostbite ◆ Is denser than air; a large release of refrigerant can displace air if you are working in a low area
3. EPA Requirements	3. Technician must be EPA-certified to handle refrigerant and repair automotive air conditioning equipment. It is illegal to vent any R-12 refrigerant to the outside atmosphere. Refrigerant must be recycled on-site or returned to a recycler. It is illegal to do any kind of air conditioner service work unless shop has EPA-certified equipment. Refrigerant must be recycled before being returned to vehicle. All refrigerants must be traceable through paperwork from purchase to disposal.

Presentation Outline	Steps to Cover/Key Points to Make
4. Types of Refrigerant	4. Major types: • HFC-134a (hydrofluorocarbon)—in use since approximately 1993 • CFC-12 (chlorofluorocarbon)—banned from introduction into ***new*** vehicles since December 1995 These terms are often shorthanded as R-134a and R-12 (R = refrigerant). It is now illegal to use any other makes and mixes. Never mix refrigerant types; it is illegal. Certain types are explosive.
5. Types of Equipment	5. Gauges—used to determine pressures and vacuum in air conditioning system Charging station—used to recharge air conditioning unit after repairs have been made Recovery/recycling station—used to recover refrigerant from vehicle; most also recycle refrigerant from vehicle Vacuum pump—used to induce a vacuum in an air conditioning system prior to charging (usually included with charging station) Refrigerant tanks—used to hold refrigerant Identifier—used to identify type of refrigerant in system
6. Verifying Equipment Operation & Maintenance	6. All equipment must be EPA-certified. Visually check the following parts for proper operation: • A/C connections • Valves • Fittings • Filters • Gauges • Electrical connections

Presentation Outline	Steps to Cover/Key Points to Make
	R-12 equipment attaches to vehicle air conditioning units using 3/8" and 7/16" fittings.
	R-134a equipment attaches to vehicle air conditioning units using quick-connect coupling.
	Units are dedicated units. Do not mix refrigerant types in units. Do not mix refrigerant oils from R-12 with oils in R-134a.
	Make sure all valves are closed prior to disconnecting and connecting refrigerant handling equipment.
	Follow equipment manufacturer's instructions concerning maintenance.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could cover ozone depletion science (what it is, how it occurs, common myths, health effects). Students could prepare papers or presentations on related topics (e.g., causes and effects of ozone depletion in the upper atmosphere or EPA regulations governing automotive air conditioning repair) in applied communication class.

Review:

Ask students review questions such as the following:

1. What different types of refrigerant handling equipment might a technician use?
2. What different types of refrigerants are used in cars?
3. What are the regulations covering the use of refrigerant handling equipment?

Application:

1. Give students illustrations of the different types of refrigerant handling equipment, and have them label each by name and indicate what type of refrigerant is used with or contained in that equipment.
2. Have students develop a procedure sheet for changing a recycler filter without releasing any refrigerant.
3. As students practice verifying the operation and maintenance of refrigerant handling equipment, quiz them individually on the process (e.g., ask them to explain the procedure for checking various parts).
4. Have students go online (to sites maintained by ASE or air conditioning parts suppliers and associations) and try to get their "609 certification" for handling refrigerants.

Evaluation:

√ Each student will verify the correct operation and maintenance of refrigerant handling equipment. His/her performance will be evaluated using a copy of the performance checklist for Competency 7.8.1.

Competency 7.8.1: Verify correct operation and maintenance of refrigerant handling equipment

Performance Checklist

In verifying the correct operation and maintenance of refrigerant handling equipment, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate equipment manufacturer's manual.	☐	☐	☐	☐	☐
4. Visually inspected each of the following recovery equipment parts for proper operation in accordance with standard procedure:					
a. A/C connections	☐	☐	☐	☐	☐
b. Valves	☐	☐	☐	☐	☐
c. Fittings	☐	☐	☐	☐	☐
d. Filters	☐	☐	☐	☐	☐
e. Gauges	☐	☐	☐	☐	☐
f. Electrical connections	☐	☐	☐	☐	☐
5. Checked equipment operation against manufacturer's specifications	☐	☐	☐	☐	☐
6. Identified all operation/maintenance problems	☐	☐	☐	☐	☐
7. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 7: Heating and Air Conditioning

Subunit 7.8: Refrigerant Recovery, Recycling, and Handling

Competency 7.8.2: Identify and recover A/C system refrigerant

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Identify and recover A/C system refrigerant
Criteria:	In accordance with the criteria in the checklist for Competency 7.8.2

Introduction:

General Introductory Techniques: Share personal experiences you have had when identifying and recovering A/C system refrigerant in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. If the refrigerant recovery process is performed incorrectly, it could damage the ozone or contaminate a container of refrigerant. All applicable guidelines and regulations ***must*** be followed.

2. Ask students whether refrigerant can be recycled if it becomes contaminated with other types of refrigerant.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Recovery regulations: • Wear protective goggles. • Ventilate the area. • Never discharge refrigerant in service area. • Never subject refrigerant to high temperatures. • Keep refrigerant away from skin. • Never leave drum uncapped. • Do not fill tank completely. • Never breath smoke. • Some "outlaw" refrigerants may be explosive. Transportation safety
3. Identifying Refrigerant in System	3. If refrigerant is to be recycled off-site— • Refer to manufacturer's label on A/C compressor to identify refrigerant. • Some combinations of contaminated refrigerant can damage the recovery equipment. If refrigerant is to be recycled on-site— • Use a refrigerant identifier unit to identify refrigerant.

Presentation Outline	Steps to Cover/Key Points to Make
4. Recovery Procedure	4. Check manufacturer's specifications. General procedure: • Connect manifold and gauge to system. • Start engine, and adjust speed to 1,250–1,500 RPM. • Set air controls to MAX cold position; set blower on high. • Reduce engine speed to 1,000–1,200 RPM, and operate 10–15 minutes. • Return engine speed to normal idle to prevent dieseling. • Turn off A/C controls. • Shut off engine. • Attach manifold and gauge set to recovery system. • Open low-side valve, and open high-side valve slowly so A/C system will retain oil. • Open any hose valves in accordance with manufacturer's instructions, and turn recovery compressor on. • Operate recovery system until system holds a small vacuum. • After all refrigerant has been removed from vehicle, close all open valves, and disconnect manifold and gauge. • Cap all fittings and hoses to keep moisture and dirt from entering system. The oil used in R-134a systems if very hygroscopic. • Check equipment valves prior to storage.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher can explain the concept *hygroscopic* and discuss chemical reactions that can occur from contaminated refrigerant.

Review:

Ask students review questions such as the following:

1. What regulations must be followed during recovery?
2. What problems can recovery of an unknown type of refrigerant lead to?
3. When should the refrigerant recovery unit be turned off?

Application:

1. Provide students with a vehicle with the refrigerant removed, and have them attach recovery system and attempt recovery. Observe students to ensure they are following the correct steps.
2. Provide students with a vehicle with an A/C system, and have them use refrigerant identifier equipment to identify the type of refrigerant.

Evaluation:

√ Each student will identify and recover A/C system refrigerant. His/her performance will be evaluated using a copy of the performance checklist for Competency 7.8.2.

Competency 7.8.2: Identify and recover A/C system refrigerant

Performance Checklist

In identifying and recovering A/C system refrigerant, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) and recovery equipment to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Accurately identified type of refrigerant in system	☐	☐	☐	☐	☐
5. Recovered refrigerant in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
6. Prepared recovery equipment for storage in accordance with regulations	☐	☐	☐	☐	☐
7. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name______________________________________**Date**______________

Unit 7: Heating and Air Conditioning

Subunit 7.8: Refrigerant Recovery, Recycling, and Handling

Competency 7.8.3: Recycle refrigerant

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Recycle refrigerant
Criteria:	In accordance with the criteria in the checklist for Competency 7.8.3

Introduction:

General Introductory Techniques: Share personal experiences you have had when recycling refrigerant in the auto tech shop. Show videos that demonstrate the steps in this process.

Competency-Specific Information:

1. Explain why all refrigerant must be recycled before being returned to a customer's car.
2. Discuss what must be done with recycled refrigerant.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Definition of Recycling	2. Recycling is removing the refrigerant and reducing the contaminants by oil separation and filter drying.
3. Contaminants Removed in Recycling Process	3. Typical contaminants: ◆ Moisture ◆ Acid ◆ Particulates Some of the newer recyclers will remove (or burp) ***air*** during the recycling process.
4. Recycling Procedure	4. Recycle refrigerant in accordance with procedure specified by manufacturer of equipment being used. Prepare used refrigerant for external recycling facility in accordance with facility's specifications.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher may present recycling information as part of lessons on the environment.

Review:

Ask students review questions such as the following:

1. What options for recycling exist?
2. What contaminants are removed?

Application:

1. Have students research the effects of contaminated refrigerant on the refrigerant handling equipment used in the shop and report on their findings.
2. Have students develop a procedure sheet for recycling refrigerant using the type of recycling equipment used in the shop.

Evaluation:

√ Each student will recycle refrigerant. His/her performance will be evaluated using a copy of the performance checklist for Competency 7.8.3.

Competency 7.8.3: Recycle refrigerant

Performance Checklist

In recycling refrigerant, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected appropriate tool(s) and refrigerant recycling equipment to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Recycled used refrigerant using one of the following methods as required by shop procedures:					
a. Cleaned and filtered used refrigerant with required procedure for the equipment used	☐	☐	☐	☐	☐
b. Prepared used refrigerant for external recycling facility in accordance with facility's specifications	☐	☐	☐	☐	☐
5. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name_______________________________________**Date**______________

Unit 7: Heating and Air Conditioning

Subunit 7.8: Refrigerant Recovery, Recycling, and Handling

Competency 7.8.4: Label and store refrigerant

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Label and store refrigerant
Criteria:	In accordance with the criteria in the checklist for Competency 7.8.4

Introduction:

General Introductory Techniques: Share personal experiences you have had when labeling and storing refrigerant in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. There should be only two types of refrigerant used in today's car: R-12 and R-134a. However, occasionally a technician will run into an air conditioner contaminated with another type of refrigerant.
2. Ask students why it is important to store different types of refrigerant in different containers.
3. Ask students to explain how to tell the difference between new and recycled R-12?

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Safety related to refrigerants: • Skin contact can cause frostbite. • Liquid can cause blindness. • Can damage respiratory system if ingested.
3. Labeling of Refrigerants	3. R-12 label should have a white background. R-134a label should have a sky blue background. (This is not to be confused with the label on another type of refrigerant known as "Hot Shot," which has a medium blue background).
4. Characteristics of Refrigerant	4. General characteristics: • Transparent and colorless • Odorless • Heavier than air and will become a vapor if released R-12 boils at –21.67°F. R-134a can be combustible under certain circumstances (if refrigerant is above atmospheric pressure and has a 60% air concentration stored with it).

Presentation Outline	Steps to Cover/Key Points to Make
5. Storing Refrigerant	5. Use only refillable cylinders for storing refrigerant. Disposable cylinders (known as DOT 39 cylinders) are ***never*** to be used to store recycled refrigerant. Refillable cylinders are color-coded: grey body with yellow top. Red valves are for vapor, and blue valves are for liquid refrigerant. R-12 cylinders have a Compressed Gas Association (CGA) fitting (#165) similar to an SAE 1/4" flare fitting. R-134a cylinders have a CGA fitting (#167) similar to an SAE M14 x 1.5 fitting. Refillable cylinders should be filled only to 80% of capacity. Store in a cool, dry place (room temperature no higher than 90°). Never expose to extreme heat or open flame. Can cause explosion. Keep valve closed tightly.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher can work with students on hazards related to refrigerants (e.g., effect of atmospheric pressure) and characteristics of solids, liquids, and gases.

Review:

Ask students review questions such as the following:

1. Why is proper labeling of refrigerant so important?
2. Describe the characteristics of a refillable cylinder.
3. Why can't DOT 39 cylinders be used to hold recovered refrigerant?

Application:

1. Have students work in teams to create their own label for R-12 as if they were the manufacturer. How would they design a label that clearly and easily communicates the cautions and warnings to the user.
2. Have students design a plan for storing recovered containers of refrigerant in the school shop in accordance with all safety practices and EPA regulations.

Evaluation:

√ Each student will label and store refrigerant. His/her performance will be evaluated using a copy of the performance checklist for Competency 7.8.4.

Competency 7.8.4: Label and store refrigerant

Performance Checklist

In labeling and storing refrigerant, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Used appropriately colored container	☐	☐	☐	☐	☐
3. Labeled refrigerant accurately	☐	☐	☐	☐	☐
4. Stored refrigerant in cool, dry area	☐	☐	☐	☐	☐
5. Ensured that valve was closed tightly	☐	☐	☐	☐	☐
6. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name______________________________________**Date**_____________

Competency 7.8.5: Test recycled refrigerant for non-condensable gases

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Test recycled refrigerant for non-condensable gases
Criteria:	In accordance with the criteria in the checklist for Competency 7.8.5

Introduction:

General Introductory Techniques: Share personal experiences you have had when testing recycled refrigerant for non-condensable gases in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Air in any reclaimed refrigerant will contain some moisture. This air is called a "non-condensable" gas by the industry.
2. Moisture in this non-condensable gas can cause an acid to form, which can damage components in the A/C system.

References:

Technical service bulletins (TSBs) and ASE's *Guide to Reclaiming/Recycling Refrigerants* (free in quantity from ASE). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling***. However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Safety related to refrigerants: ◆ Skin contact can cause frostbite. ◆ Liquid can cause blindness. ◆ Can damage respiratory system if ingested.
3. Testing for Non-Condensable Gases	3. Refer to TSBs for latest information. General procedures: ◆ After refrigerant has been run through its recycling procedure, it will be warmer than room temperature. ◆ Identify type of refrigerant, and obtain appropriate temperature/pressure chart. ◆ Attach a manifold gauge: low side to the tank (low side); and high side to the tank (high side). ◆ Note gauge readings, keeping in mind the refrigerant's temperature/pressure relationship. Write the readings down. ◆ Allow a few hours for recycled tank to stabilize to room temperature. ◆ Note room temperature (°F or °C), and compare it to gauge readings for the recycled tank (again, keeping in mind the refrigerant's temperature/pressure relationship). Write down the new gauge readings.

Presentation Outline	Steps to Cover/Key Points to Make
	• If the room-temperature refrigerant now is within manufacturer's pressures, it has no abnormal amount of air (non-condensable gases). • If it has higher than normal readings, it contains air (non-condensable gases). This air must be purged from the tank. • Purge air using the same procedure as for purging air from lines of the installed gauges (7.4.6).

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could help students with temperature-pressure relationship charts.

Review:

Ask students review questions such as the following:

1. Should the low-side gauge reading differ from the high-side gauge reading when connected to a tank of recycled refrigerant? Why or why not?
2. How can you tell if a cooled-down tank of recycled refrigerant contains any non-condensable gases?

Application:

1. Have students prepare a procedure sheet for testing recycled refrigerant for non-condensable gases that can be used to guide student practice in the lab.
2. Give students a teacher-prepared diagram, and have them label gauge-to-tank connections and then indicate how gauge readings should differ from warm, recycled refrigerant to cooled-down normal (no non-condensable gases) refrigerant at room temperature.

Evaluation:

√ Each student will test recycled refrigerant for non-condensable gases. His/her performance will be evaluated using a copy of the performance checklist for Competency 7.8.5.

Competency 7.8.5: Test recycled refrigerant for non-condensable gases

Performance Checklist

In testing recycled refrigerant for non-condensable gases, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected appropriate tool(s) and test equipment to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Tested refrigerant for non-condensable gases in accordance with standard procedures	☐	☐	☐	☐	☐
5. Accurately noted all gauge readings	☐	☐	☐	☐	☐
6. Accurately identified manufacturer's pressures	☐	☐	☐	☐	☐
7. Purged any air in accordance with standard procedure	☐	☐	☐	☐	☐
8. Performed complete final visual inspection	☐	☐	☐	☐	☐
9. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name_______________________________________**Date**_____________

Unit 7: Heating and Air Conditioning

Subunit 7.8: Refrigerant Recovery, Recycling, and Handling

Competency 7.8.6: Evacuate and charge A/C system

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Evacuate and charge an A/C system
Criteria:	In accordance with the criteria in the checklist for Competency 7.8.6

Introduction:

General Introductory Techniques: Share personal experiences you have had when evacuating and charging A/C systems in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Charging an automotive air conditioning system involves putting refrigerant back into the system. If everything is done right at this point, you will be cool.

2. Ask students if they have ever heard of someone who charged an air conditioning system only to have all the refrigerant leak out. What should have been done to prevent this?

3. Ask students if a system would cool better if more refrigerant were added to it.

4. Ask students in which form refrigerant should be added to the system: liquid or vapor.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Definition of Evacuation	2. Evacuation involves attaching vacuum pump to the system to remove air and moisture.
3. Charging Methods	3. Pound cans: • These are small cans of refrigerant used to charge systems. • R-12 comes in 14-oz cans. • R-134a comes in 12-oz cans. • Add the weight of cans for approximate correct amount of refrigerant needed in the system. • Pound cans are being phased out. Bulk containers: • Bulk containers come in sizes 10 lb or larger. • Place bulk container on a scale, and note correct amount of refrigerant used. Charging stations: • Charging stations include the gauges and bulk container with the station. • They allow for a controlled amount of refrigerant to be added without constant monitoring of the charging process.

Presentation Outline	Steps to Cover/Key Points to Make
	Liquid charge vs. vapor charge: ◆ Some air conditioning systems (e.g., orifice tube and accumulator type) recommend never adding liquid to the high side of an A/C system. ◆ Adding liquid to the high side can damage the A/C compressor.
4. Evacuating & Charging Procedure	4. Setup for evacuating and charging system Low pressure gauge levels Vacuum holding—no more than 2 in. drop in 5 minutes Partial charge for leak testing (follow manufacturer's specifications) Methods of charging will vary with— ◆ Type of refrigerant container ◆ Type of A/C system Follow manufacturer's specifications.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could provide lessons on vacuums. The applied mathematics teacher could work with students on calculating refrigerant amounts and use of scales.

Review:

Ask students review questions such as the following:

1. What is a typical charging station used for?
2. What are two supply sources for system charging?
3. What is the benefit of having a complete charging station?
4. What is the advantage of charging with a liquid? What can be damaged with a liquid charge?

Application:

1. Give students a teacher-prepared illustration of an evacuating and charging system, and have them label the parts.
2. Provide students with a refrigerant supply (pound cans or bulk container) and a particular type of A/C system, and have them determine the proper charging procedure.
3. As students practice evacuating an air conditioning system, quiz them individually on the process (e.g., ask them to describe how to determine whether there are any leaks present).

Evaluation:

√ Each student will evacuate and charge an A/C system. His/her performance will be evaluated using a copy of the performance checklist for Competency 7.8.6.

Competency 7.8.6: Evacuate and charge A/C system

Performance Checklist

In evacuating and charging an A/C system, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected appropriate tool(s) and equipment to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Evacuated system according to manufacturer's procedure	☐	☐	☐	☐	☐
5. Determined type of refrigerant required	☐	☐	☐	☐	☐
6. Charged A/C system according to manufacturer's specifications	☐	☐	☐	☐	☐
7. Performed complete final visual inspection	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

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Units 1/8: Engine Repair/Engine Performance

Subunits 1.1/8.1: General Engine Diagnosis; Removal and Reinstallation (R & R)

Competencies 1.1.1/8.1.1: Interpret and verify complaint; determine needed repairs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Interpret and verify a customer concern, and determine needed repairs
Criteria:	In accordance with the criteria in the checklist for Competencies 1.1.1/8.1.1

Introduction:

General Introductory Techniques: Share personal experiences you have had when interpreting and verifying customer concerns in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Explain that auto technicians need to listen to customer concerns; customers know how their vehicles typically perform—and they can often provide useful information when those vehicles are not performing as usual. Discussing the information they provide—along with what you, as auto technicians, know about vehicle operation—can assist you in diagnosing and troubleshooting problems and determining needed repairs.

2. Ask students: What types of questions would you ask to help the customer explain his or her vehicle's problem(s)?

3. Ask students: What could you do to let the customer know you are paying attention to his or her explanation and genuinely concerned about the problem?

References:

Technical service bulletins (TSBs); "Noise Description" handouts available from local car dealerships. (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Importance of Accurate Diagnosis	2. ***Remember:*** The key to building reputation is, "If it's not broken, don't fix it." Stay focused on customer's concerns and vehicle problem.
3. Interviewing the Customer	3. Pay attention and listen carefully to the customer. Provide feedback (e.g., nod or say "okay" or "tell me more") to indicate that you are hearing what the customer is saying. Show genuine empathy for the customer's concern. Never "talk down" to a customer. You are the technician—the expert—but be courteous. Ask probing questions (e.g., "At what speed or temperature does that occur?" or "Please describe for me exactly what it sounds like").
4. Recording Information	4. Take notes during the interview to record the key points emphasized.
5. Looking Up Information	5. Refer to TSBs and service manuals. These resources contain technical information and cues that will help you diagnose and verify the complaint/ problem.

Presentation Outline	Steps to Cover/Key Points to Make
6. Finding the Problem	6. Look, listen, feel, probe, and disassemble as needed to gain access to vehicle components. Perform actions necessary to demonstrate/duplicate problem described.
7. Determining Needed Repairs	7. Using diagnostic information gathered, refer to service manuals to identify needed repairs.

> ***Note:*** The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.
>
> For example, the applied communications teacher may help students with interviewing techniques, design of probing questions, and recording of pertinent information.

Review:

Ask students review questions such as the following:

1. How important is it for the auto technician to make an accurate diagnosis of the vehicle's problem?

2. Why is it important to show empathy toward the customer and concern for the customer's vehicle?

3. What types of questions would be appropriate to ask the customer to help identify the problem?

Application:

1. Have students develop an interview form with sample questions to ask customers and devices (e.g., checklists) to use in recording the customer's responses quickly and accurately.

2. Have students divide into pairs and role-play the interview process. For example, school personnel or students in other classes could be interviewed about vehicle problems they are experiencing or have experienced in the past.

3. Give students written case studies describing customers' explanations of their vehicle problems. Have the students list step by step exactly how they would proceed in order to interpret and verify each customer's concern(s).

Evaluation:

√ Each student will interpret and verify a customer concern and determine needed repairs. His/her performance will be evaluated using a copy of the performance checklist for Competencies 1.1.1/8.1.1.

Competencies 1.1.1/8.1.1: Interpret and verify complaint; determine needed repairs

Performance Checklist

In interpreting and verifying a customer concern and determining needed repairs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Interviewed customer to verify problem	☐	☐	☐	☐	☐
4. Paid attention and listened to customer	☐	☐	☐	☐	☐
5. Was courteous and empathetic	☐	☐	☐	☐	☐
6. Asked probing questions that would help identify problem	☐	☐	☐	☐	☐
7. Referred to appropriate technical service bulletins and/or service manuals	☐	☐	☐	☐	☐
8. Accurately recorded key points made during interview	☐	☐	☐	☐	☐
9. Performed actions necessary to demonstrate/duplicate problem described	☐	☐	☐	☐	☐
10. Determined needed repairs	☐	☐	☐	☐	☐
11. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name_______________________________________ **Date**_____________

Unit 8: Engine Performance

Subunit 8.1: General Engine Diagnosis

Competency 8.1.5: Perform engine absolute (vacuum/boost) manifold pressure tests; determine needed repairs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Perform an engine absolute manifold pressure test, and determine needed repairs
Criteria:	In accordance with the criteria in the checklist for Competency 8.1.5

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when performing engine absolute manifold pressure tests and determining needed repairs. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. We test engine vacuum in order to test the following:
   - Engine's sealing ability
   - Valve and ignition timing
   - Exhaust back pressure
   - Boost pressure from turbo unit
   - Amount of pressure being produced

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Cautions regarding moving parts Exhaust removal system requirements
3. Engine Pressure/Vacuum Gauge	3. Types Features
4. Engine Vacuum/Boost	4. How a vacuum/boost is created What affects it
5. Performing Vacuum/Boost Test	5. Use of equipment and procedures specified by manufacturer Testing procedure for a specific vehicle Typical problems indicated by specific readings (refer to service manual): • Worn piston rings • Sticking engine valve • Spark plug not firing • Burned valve • Retarded spark • Incorrect timing

Presentation Outline	Steps to Cover/Key Points to Make
	◆ Intake manifold leak ◆ Back pressure in the exhaust system ◆ Weak valve springs ◆ Cylinder head gasket leak
6. Determining Needed Repairs	6. Using diagnostic information gathered, refer to service manuals to identify needed repairs.

> ***Note:*** The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.
>
> For example, the applied mathematics teacher could work with students on converting psi (standard) to kPa (metric).

Review:

Ask students review questions such as the following:

1. Why is it important to test the engine vacuum?
2. What conditions may affect the vacuum test?
3. If a vehicle has low engine vacuum, overboost condition, and restricted exhaust, what might be the problem?

Application:

1. As students practice performing engine manifold pressure tests, quiz them individually on the process (e.g., ask them to describe how to use the vacuum test gauge and exactly what to look for when performing the test).
2. Give students a sheet indicating test results, and have them list the possible repairs needed.

Evaluation:

√ Each student will perform an engine absolute manifold pressure test and determine needed repairs. His/her performance will be evaluated using a copy of the performance checklist for Competency 8.1.5.

Competency 8.1.5: Perform engine absolute (vacuum/boost) manifold pressure tests; determine needed repairs

Performance Checklist

In performing an engine absolute manifold pressure test and determining needed repairs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct gauge in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Performed engine absolute vacuum manifold pressure test (boost if needed) in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
5. Determined needed repairs	☐	☐	☐	☐	☐
6. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Units 1/8: Engine Repair/Engine Performance

Subunits 1.1/8.1: General Engine Diagnosis; Removal and Reinstallation (R & R)

Competencies 1.1.6/8.1.6: Perform cylinder power balance tests; determine needed repairs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Perform a cylinder power balance test, and determine needed repairs
Criteria:	In accordance with the criteria in the checklist for Competencies 1.1.6/8.1.6

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when performing cylinder power balance tests and determining needed repairs. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. There must be a ***balance of power*** within the engine in accordance with the manufacturer's specifications.

2. A cylinder power balance test allows you to quickly determine whether all of the engine's cylinders are producing the same amount of power.

References:

Technical service bulletins (TSBs), Analyzer's Hook-up Instructions. (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Be constantly aware of moving parts in the engine compartment as you perform the cylinder power balance test. Exhaust removal system ***must*** be used when engine is running inside the auto shop. Exhaust can be deadly!
3. Rationale for Testing Power Balance	3. Ideally all cylinders should produce the same amount of power, This minimizes the power losses that occur when some cylinders have to keep a "weak" one going or "in balance" with the others. A power balance test can signify problems with valves, leaky intake or cylinder head gaskets, piston rings, and fuel or ignition systems. It can locate misfires, a dead miss, or a weak cylinder.
4. Test Tools	4. Engine analyzer Tachometer Ground wires

Presentation Outline	Steps to Cover/Key Points to Make
5. Performing Power Balance Test	5. Engine should be at operating temperature when being checked. More than one way to test: ◆ Connect tachometer and remove the plug wires one by one to check performance. ◆ Connect engine analyzer, then "short-out" one cylinder at a time to determine each cylinder's performance. ◆ Measure "power change" by the RPM drop on the tachometer when the cylinder is shorted-out. Test RPM drop of each individual cylinder (as compared to other cylinders) using hookup procedure specified by manufacturer.
6. Standard Precautions When Performing Tests	6. Electronic ignition vehicles: ◆ When removing plug wire, do not leave an excessive gap between plug wire and ground. Doing so could damage the system. ◆ Attach a spark tester to plug wire, then ground it prior to running vehicle on each cylinder. If vehicle is EGR-equipped, consult service manual for precautions. Manual must be followed to prevent damage. ***Know the vehicle!*** If vehicle is equipped with a catalytic converter, do not run for more than 15–60 seconds with plug shorted-out. This will help prevent too much unburned fuel from entering the system and possibly causing damage. Also, allow the engine to run 30–60 seconds after reconnecting the plug so that the engine and converter can stabilize prior to your testing of the next cylinder. If vehicle has an Oxygen Sensor, feedback-type carburetor, and/or AIR system, refer to manufacturer's information prior to testing.

Presentation Outline	Steps to Cover/Key Points to Make
7. Analyzing Test Results	7. Each cylinder's RPM drop should be within 10% of that of other cylinders. When reviewing the RPM drop, note the cylinder(s) having the lowest RPMs or the highest amount of RPM drop. These are the weaker cylinder(s).
8. Determining Needed Repairs	8. Using diagnostic information gathered, refer to service manuals to identify needed repairs.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher may assist students in understanding RPMs.

Review:

Ask students review questions such as the following:

1. Why should all engine cylinders produce basically the same amount of power?
2. If the power being produced by each engine cylinder is not the same, what are some likely causes of this imbalance?
3. If a customer came into the shop and told you that his or her vehicle was idling rough, how would performing a power balance test assist you in identifying the idling problem?

Application:

1. As students practice performing a cylinder power balance test, quiz them individually on the process (e.g., ask them to itemize the precautions to be taken during the testing process, including the related safety concerns).
2. Give students a sample power balance sheet, and have them identify possible causes of problem.

Evaluation:

√ Each student will perform a cylinder power balance test and determine needed repairs. His/her performance will be evaluated using a copy of the performance checklist for Competencies 1.1.6/8.1.6.

Competencies 1.1.6/8.1.6: Perform cylinder power balance tests; determine needed repairs

Performance Checklist

In performing a cylinder power balance test and determining needed repairs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Ensured that engine was at normal operating temperature	☐	☐	☐	☐	☐
5. Performed cylinder power balance test in accordance with service procedures	☐	☐	☐	☐	☐
6. Took standard precautions during testing related to specific vehicle being tested (e.g., electronic ignition, EGR-equipped, catalytic converter, Oxygen Sensor feedback-type carburetor or AIR system)	☐	☐	☐	☐	☐
7. Analyzed test results	☐	☐	☐	☐	☐
8. Identified the cylinder(s) with the lowest RPMs or highest amount of RPM drop	☐	☐	☐	☐	☐
9. Determined needed repairs	☐	☐	☐	☐	☐
10. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name______________________________________**Date**_____________

Units 1/8: Engine Repair/Engine Performance

Subunits 1.1/8.1: General Engine Diagnosis; Removal and Reinstallation (R & R)

Competencies 1.1.7/8.1.7: Perform cylinder compression tests; determine needed repairs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Perform a cylinder compression test, and determine needed repairs
Criteria:	In accordance with the criteria in the checklist for Competencies 1.1.7/8.1.7

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when performing cylinder compression tests and determining needed repairs. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. When trying to identify engine performance problems, it is often wise and necessary to perform cylinder compression tests. This type of test helps determine whether the engine is worn to the point of needing internal repairs.

2. Ask students: What types of questions might you ask a customer to help determine whether there is an engine performance problem?

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Be aware of moving components in the engine compartment. Be aware of hot engine components.
3. Engine Compression	3. Engine compression is the pressure created in the engine during the compression stroke when the piston compresses the air/fuel mixture. In a four-stroke cycle, each stroke affects the other. Low compression has a major effect on power output. Must have a good sealing container.
4. Test Tools	4. Compression test kit Oil squirt can Battery charger Remote starter
5. Performing Cylinder Compression Test	5. Test is performed to check two main components for their sealing capability: valves and piston rings. Follow procedure sheet per manufacturer's recommendations.

Presentation Outline	Steps to Cover/Key Points to Make
	General procedure: • Warm engine (thermostat open to normal operating temperature). • Place transmission in PARK or NEUTRAL, apply parking brake, and block drive wheels. • Disable vehicle from starting. • Hook up battery charger, and place on low. • Install remote starter • Remove all spark plugs. (It's very helpful to label each spark plug wire. You can use clothes pins with cylinder ID info written on the ends.) • Block the throttle wide open to allow maximum air flow into each cylinder. • Install compression gauge kit in #1 spark plug hole. • Crank engine required number of revolutions or gauge needle "jumps" per manufacturer's guidelines (e.g., minimum of 5 seconds). • Repeat procedure for each cylinder. • Record gauge readings for each cylinder as tested.
6. Analyzing Results/Performing Wet Test	6. Compare results to manufacturer's specifications. If reading is still low (e.g., below 100 psi or more than 10%), do the following: • Remove tester. • Add approximately 1 tsp of motor oil to the cylinder. • Repeat test. • Note reading.

Presentation Outline	Steps to Cover/Key Points to Make
7. Determining Needed Repairs	7. Possible Diagnoses If low reading rises after oil is added: • Rings not sealing If reading doesn't come up: • Valve, head, or gasket problem If two cylinders side-by-side are low: • Head or gasket problem If all cylinders are low (blow 100psi): • Worn engine • Incorrect valve timing

> ***Note:*** The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.
>
> For example, the applied mathematics teacher could deal with bore and stroke and the volume of air in the cylinder.

Review:

Ask students review questions such as the following:

1. What effect does poor (low) compression have on an engine?
2. Why is it important to have the engine at normal operating temperature prior to performing the compression test?

Application:

1. As students practice performing cylinder compression tests, quiz them individually on the process (e.g., ask them to explain how to keep the spark plug wires in order while disconnecting them).
2. Have students prepare a readings sheet and then use it to record findings during the compression test.

Evaluation:

√ Each student will perform a cylinder compression test and determine needed repairs. His/her performance will be evaluated using a copy of the performance checklist for Competencies 1.1.7/8.1.7.

Competencies 1.1.7/8.1.7: Perform cylinder compression tests; determine needed repairs

Performance Checklist

In performing a cylinder compression test and determining needed repairs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Ensured that engine was at normal operating temperature	☐	☐	☐	☐	☐
5. Performed cylinder compression test in accordance with service procedures, including:					
a. removed and labeled all spark plugs	☐	☐	☐	☐	☐
b. held throttle wide open for maximum air flow	☐	☐	☐	☐	☐
c. stabilized vehicle (e.g., parking brake on)	☐	☐	☐	☐	☐
d. disabled ignition system	☐	☐	☐	☐	☐
e. cranked engine required number of revolutions or gauge needle "jumps"	☐	☐	☐	☐	☐
6. Recorded readings for each cylinder	☐	☐	☐	☐	☐
7. Analyzed test results by comparing readings to manufacturer's specifications	☐	☐	☐	☐	☐
8. Ran a "wet test" on low cylinders	☐	☐	☐	☐	☐
9. Determined needed repairs	☐	☐	☐	☐	☐
10. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Units 1/8: Engine Repair/Engine Performance

Subunits 1.1/8.1: General Engine Diagnosis; Removal and Reinstallation (R & R)

Competencies 1.1.8/8.1.8: Perform cylinder leakage tests; determine needed repairs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Perform a cylinder leakage test and determine needed repairs
Criteria:	In accordance with the criteria in the checklist for Competencies 1.1.8/8.1.8

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when performing cylinder leakage tests and determining needed repairs. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Let's assume you are trying to identify the cause(s) of engine performance problems. You perform a cylinder compression test and note a loss of compression. Where did it go?

2. You need to check inside the engine to pinpoint exactly what is causing the loss of compression. This is the time to perform a cylinder leakage test.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Use caution when working on a warm engine; components may be ***hot***. Be aware of moving components in the engine compartment when shop air is connected to the tester.
3. Identifying Source of Compression Loss	3. Possible places to lose compression: valves, rings, head gasket, or intake gasket Poor maintenance is usually the cause of the problem (wear).
4. Cylinder Leakage Tester	4. Description Operation
5. Performing Cylinder Leakage Test	5. Always follow vehicle manufacturer's guidelines and tester manufacturer's instructions when performing the test. Hookup procedure: ◆ Place vehicle in NEUTRAL (standard transmission) or PARK (automatic transmission. ◆ Remove spark plugs. ◆ Make sure cylinder is near BOC compression stroke. ◆ Install test kit in spark plug hole. ◆ Hook up air supply.

Presentation Outline	Steps to Cover/Key Points to Make
	Testing procedure: • With radiator cap off, run engine until it reaches its normal operating temperature (when the thermostat opens, coolant flows into radiator). ***Leave the cap off during the test.*** • Bring the Number 1 cylinder up to TDC (compression stroke). • Calibrate tester per instructions. • Install tester in cylinder per instructions. • Note and record the "% Leakage" reading. Repeat this procedure for each cylinder. (***Note:*** each cylinder must be brought up to its TDC compression prior to the test.) Readings of a certain percentage (e.g., 10%) or greater indicate a problem. Check manufacturer's specifications for specific percentage. Check (listen to) all areas where leaks can occur: • Tailpipe—exhaust valve • Intake/carburetor/throttle body—intake valve • PVC/Oil fill cap—piston rings • Bubbles in radiator—head or intake gasket, crack in block or cylinder head ***Note:*** Most vehicles (even new ones) will have leakage past the piston rings. Check manufacturer's specifications for leakage percentage that is generally acceptable (e.g., up to 20%).
6. Determining Needed Repairs	6. Using diagnostic information gathered, refer to service manuals to identify needed repairs. Possible Diagnoses If air is escaping from throttle: • Intake valve problem

Presentation Outline	Steps to Cover/Key Points to Make
	If air is escaping from exhaust:
	- Exhaust valve problem
	If air is escaping from oil cap:
	- Ring problem
	If air is escaping from radiator:
	- Head gasket problem
	- Cracked head

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher may help students with analysis of compression.

Review:

Ask students review questions such as the following:

1. In what locations inside the engine would you find "cylinder leakage"?
2. What potential problems may be caused when air is heard coming out of the exhaust tailpipe during the cylinder leakage test?
3. What percent cylinder leakage indicates a bad cylinder?
4. If you see bubbles in the radiator during the cylinder leakage test, what should this alert you to?

Application:

1. Have students develop a chart listing where leaks are heard on a vehicle (Column 1) and the possible causes for each (Column 2). This can be done on an individual, small-group, or whole-class basis.
2. Assign selected students to present an overview to the class of the procedure for performing the cylinder leakage test.

Evaluation:

√ Each student will perform a cylinder leakage test and determine needed repairs. His/her performance will be evaluated using a copy of the performance checklist for Competencies 1.1.8/8.1.8.

Competencies 1.1.8/8.1.8: Perform cylinder leakage tests; determine needed repairs

Performance Checklist

In performing a cylinder leakage test and determining needed repairs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Warmed up the engine to normal operating temperature	☐	☐	☐	☐	☐
5. Kept radiator cap off during both warm up and testing	☐	☐	☐	☐	☐
6. Brought Number 1 cylinder up to TDC	☐	☐	☐	☐	☐
7. Calibrated tester per instructions	☐	☐	☐	☐	☐
8. Installed tester in cylinder per instructions	☐	☐	☐	☐	☐
9. Recorded "% Leakage" reading correctly	☐	☐	☐	☐	☐
10. Repeated procedure for each cylinder	☐	☐	☐	☐	☐
11. Identified possible problem areas through analysis of results	☐	☐	☐	☐	☐
12. Listened to areas where leaks could occur	☐	☐	☐	☐	☐
13. Determined needed repairs	☐	☐	☐	☐	☐
14. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 8: Engine Performance

Subunit 8.1: General Engine Diagnosis

Competency 8.1.9:	Diagnose engine mechanical, electrical, electronic, fuel, and ignition problems with an oscilloscope and engine diagnostic equipment; determine needed action

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Diagnose engine problems with an oscilloscope and engine diagnostic equipment, and determine needed action
Criteria:	In accordance with the criteria in the checklist for Competency 8.1.9

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when diagnosing engine problems with an oscilloscope and engine diagnostic equipment and determining needed action. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Customers want their vehicles to function at 100% at all times. When they have problems with their vehicles, they expect the auto technician to be able to diagnose specifically what is causing the problem and determine what needs to be repaired.

2. The oscilloscope and engine diagnostic equipment are very important pieces of equipment for the technician to use in diagnosing a problem.

3. Note that it is ***not*** the equipment that "tells you the problem" but how ***you*** interpret this information and determine where the trouble really is.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Cautions regarding moving parts Exhaust removal system requirements
3. Preparation	3. Review test results from prior tests (e.g., compression, cylinder leakage, power balance). Was a problem found? If so, was it fixed, or does it still exist?
4. Using an Oscilloscope	4. ***Purpose:*** To analyze engine functions (RPM, vacuum, ignition patterns) in order to find malfunctions Hookup procedure (in accordance with manufacturer's specifications), including placement of battery leads, ignition leads, vacuum hose Identification of specific faults (e.g., shorted ignition wire, open wire, bad plug) via differences in scope patterns Ignition patterns display: • Spark line • Firing line • Dwell section • Primary Analysis of scope results

Presentation Outline	Steps to Cover/Key Points to Make
5. Determining Needed Repairs	5. Using information from previous test results and diagnostic information gathered using the oscilloscope, refer to service manuals to identify needed repairs.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science or mathematics teacher could help students with abbreviated terms on scope (e.g., kv, ms, in. of mercury).

Review:

Ask students review questions such as the following:

1. How does the spark line differ for a shorted wire vs. an open wire?
2. How can referencing the TSB help you in your diagnosis?

Application:

1. Have students divide into teams and practice using the oscilloscope by creating faults and interpreting the readings.
2. Create a problem on a vehicle, and have students attach it to the oscilloscope and then explain their findings.

Evaluation:

√ Each student will diagnose engine problems with an oscilloscope and engine diagnostic equipment and determine needed action. His/her performance will be evaluated using a copy of the performance checklist for Competency 8.1.9.

Competency 8.1.9: Diagnose engine mechanical, electrical, electronic, fuel, and ignition problems with an oscilloscope and engine diagnostic equipment; determine needed action

Performance Checklist

In diagnosing engine problems with an oscilloscope and engine diagnostic equipment and determining needed action, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Reviewed prior test results	☐	☐	☐	☐	☐
5. Identified problems still existing	☐	☐	☐	☐	☐
6. Hooked up oscilloscope in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
7. Identified specific faults using scope patterns	☐	☐	☐	☐	☐
8. Determined needed repairs	☐	☐	☐	☐	☐
9. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competency 8.1.10: Prepare 4- or 5-gas analyzer; inspect and prepare vehicle for test and obtain exhaust readings; interpret readings and determine needed action

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Test the exhaust content of a vehicle using a 4- or 5-gas analyzer, and determine needed action
Criteria:	In accordance with the criteria in the checklist for Competency 8.1.10

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when obtaining and interpreting exhaust readings and determining needed actions. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Many state environmental protection agencies require that each vehicle exhaust system be inspected to ensure that exhaust content is within the normal value as prescribed by the state. This is a very important task for the auto technician.

2. Usually, only licensed technicians are qualified to perform the test to certify a vehicle for operation.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Cautions regarding moving parts Exhaust removal system requirements
3. Gas Analyzer	3. Probe is placed in exhaust pipe to obtain sample. Sample is analyzed to determine contents (e.g., hydrocarbons, oxygen, carbon monoxide, carbon dioxide, oxides of nitrogen).
4. Exhaust Contents/Normal Values	4. EPA specifications for the following pollutants vary depending on model year and whether vehicle is equipped with a particular emission-control system (federal, high-altitude, heavy-duty, California): ***Hydrocarbons (HC)*** • Unburned fuel • Measured in ppm (parts per million) • Recommended normal value: below 100 ppm ***Oxygen (O_2)*** • Measured in % • Recommended normal value: less than 1%

Presentation Outline	Steps to Cover/Key Points to Make
	Carbon dioxide (CO_2) • Measured in % • Recommended normal value: over 10% ***Carbon monoxide (CO)*** • Measured in % • Recommended normal value: 3.4% ***Oxides of nitrogen (NO_X)*** • Measured in ppm (parts per million) • Recommended normal value: .20 (200ppm)
5. Using Analyzer to Obtain Exhaust Readings	5. Importance of following manufacturer's specifications General procedure for each of the following steps: • Prepare analyzer • Prepare vehicle • Inspect vehicle • Obtain readings • Record readings
6. Interpreting Readings	6. Determine whether readings are within the normal value range as prescribed by state guidelines.
7. Determining Needed Repairs	7. Using diagnostic information gathered, refer to service manuals to identify needed repairs. Further testing may be needed to identify fault. Problem may be related to fuel, ignition, mechanical, or emission systems.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher can work with students on pollutants and chemical composition. The applied mathematics teacher can help students in understanding ppm and percentages.

Review:

Ask students review questions such as the following:

1. Which state agency identifies acceptable exhaust emission content values? Where can you find the state information requirements?
2. What are the normal exhaust readings for this state?
3. What kinds of conditions can affect exhaust readings?
4. How would you correct a high HC reading? a high O_2 reading?

Application:

1. Have students prepare a procedure sheet for inspecting and preparing a vehicle for a gas analyzer test and obtaining exhaust readings.
2. Present teams of students with several different exhaust readings, and have them decide what should be done with a vehicle with each given reading.

Evaluation:

√ Each student will test the exhaust content of a vehicle using a 4- or 5-gas analyzer and determine needed action. His/her performance will be evaluated using a copy of the performance checklist for Competency 8.1.10.

Competency 8.1.10: Prepare 4- or 5-gas analyzer; inspect and prepare vehicle for test and obtain exhaust readings; interpret readings and determine needed action

Performance Checklist

In testing the exhaust content of a vehicle using a 4- or 5-gas analyzer and determining needed action, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Performed each of the following steps in accordance with manufacturer's specifications:					
a. Prepared gas analyzer	☐	☐	☐	☐	☐
b. Inspected vehicle	☐	☐	☐	☐	☐
c. Prepared vehicle for exhaust gas test	☐	☐	☐	☐	☐
d. Obtained exhaust readings	☐	☐	☐	☐	☐
5. Recorded exhaust readings accurately	☐	☐	☐	☐	☐
6. Correctly interpreted readings obtained by analyzer	☐	☐	☐	☐	☐
7. Determined needed repairs	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 8: Engine Performance

Subunit 8.2: Computerized Engine Controls Diagnosis and Repair

Competency 8.2.2: Retrieve and record stored diagnostic trouble codes

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Retrieve and record stored diagnostic trouble codes
Criteria:	In accordance with the criteria in the checklist for Competency 8.2.2

Introduction:

General Introductory Techniques: Share personal experiences you have had when retrieving and recording stored diagnostic trouble codes in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. When the "check engine" light or MIL (Malfunction Indicator Lamp) illuminates on the vehicle dashboard, it could mean many things.

2. To determine the specific nature of the problem, you need to be able to retrieve ***and*** interpret the diagnostic trouble codes.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Cautions regarding moving parts Exhaust removal system requirements
3. Hooking Up Test Equipment	3. Use of equipment specified by manufacturer Hookup procedure for type of equipment specified Testing procedure for type of equipment specified
4. Retrieving/Recording Codes	4. It is very, very important to identify correct code number for the specific vehicle and to record it accurately for future reference. Always double-check code numbers for accuracy.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied communications teacher could help students with understanding how to use reference manuals and interpret abbreviations.

Review:

Ask students review questions such as the following:

1. Why is it important to write the code on a piece of paper?
2. Why is it important to maintain a history of the diagnostic code troubleshooting procedure for each vehicle?

Application:

1. Have students practice retrieving and recording diagnostic codes on operable vehicles using ***scan tool*** techniques.
2. Have students practice retrieving and recording diagnostic codes on operable vehicles using ***manual*** techniques.

Evaluation:

√ Each student will retrieve and record stored diagnostic trouble codes. His/her performance will be evaluated using a copy of the performance checklist for Competency 8.2.2.

Competency 8.2.2: Retrieve and record stored diagnostic trouble codes

Performance Checklist

In retrieving and recording stored diagnostic trouble codes, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected appropriate test equipment for vehicle	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Hooked up equipment in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
5. Retrieved diagnostic code number(s)	☐	☐	☐	☐	☐
6. Documented code number(s) accurately	☐	☐	☐	☐	☐
7. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Units 6/8: Electrical/Electronic Systems/Engine Performance

Subunits 6.1/8.2: General Electrical System Diagnosis/Computerized Engine Controls Diagnosis and Repair

Competency 6.1.3:	Check voltage and voltage drop in electrical/electronic circuits using a digital multimeter (DMM); determine needed repairs
Competency 8.2.5:	Obtain and interpret digital multimeter (DMM) readings

Competency Development Guide

Objective:

Condition: Provided with an electrical/electronic circuit and while following all applicable safety guidelines

Behavior: Obtain and interpret DMM readings

Criteria: In accordance with the criteria in the checklist for Competencies 6.1.3/8.2.5

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when checking voltage and voltage drop using a DMM. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Explain that if there is one tool that today's technicians use in almost every area of the car, it is the digital multimeter (DMM).

2. Ask students to summarize the difference between an ampere and a volt.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Note: There is a good deal of overlap in the competencies in this subunit. Competency 6.1.6 (now combined with 8.2.8) is where students focus on actually finding shorts, grounds, opens, and resistance problems in circuits and determining needed repairs. These earlier lessons should focus instead on how to use the ***tools*** for finding circuit problems: wiring diagrams, DMM, and ammeter.

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Basic Electricity/Electronic Principles	2. Why we measure electricity How we measure electricity Key concepts/terms: • Load—an electrical device, such as a light bulb, that requires electrical current to operate. The voltage drops from one side of the load to the other. • Direct current—electricity travels one way. • Alternating current—electricity travels both ways. Review of other principles as needed (6.1.1)
3. Digital Multimeter (DMM)	3. DMM is a voltmeter, ammeter, and ohmmeter all in one. Also called a digital volt ohmmeter (DVOM). Allows you to obtain accurate measures of circuit values. By comparing the values obtained to known "good" values, you can identify problems.
4. Connecting DMM	4. Normal procedure for connecting DMM to circuit ***Remember:*** Keep leads away from moving parts.

Presentation Outline	Steps to Cover/Key Points to Make
5. Checking Voltage	5. Procedure for checking voltage using DMM, including— • Test on live circuits. • Set controls. • Hook meter in parallel to circuit. Power must be on.
6. Checking Resistance	6. Procedure for checking resistance using DMM, including— • Test on dead circuits. • Set controls. • Circuit must be isolated. Power must be off.
7. Checking Amperage	7. Procedure for checking amperage using DMM, including— • Use inductive clamps in series. • Set controls. • Hook up with inductive clamp or in series with the circuit being tested (make sure amperage rating of circuit does not exceed amperage rating of DMM). ***Caution:*** If amperage rating of circuit ***does*** exceed amperage rating of DMM, it could blow a fuse or damage the electrical circuits in DMM or, in severe cases, cause DMM to blow up. • Power to circuit should be on after tester is hooked up.

Presentation Outline	Steps to Cover/Key Points to Make
8. Identifying Voltage Drops	8. Definition: Voltage drop is the decrease in voltage as current passes through a resistance. Refer to manufacturer's specifications for voltage drops. Some manufacturers will specify different limits for ground voltage drops (500mv, 200mv, etc.) Formula for calculating voltage drop: • Ohm's law: $E = I \times R$ Method for measuring voltage drop across a resistance: • Check voltage going into the resistance, and compare it to the voltage coming out of the resistance. The difference is the voltage drop. • Amperage stays the same in a series circuit, but voltage is used in going through a resistance.
9. Interpreting Readings	9. High readings Low readings Open readings Zero readings

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

Throughout Unit 6, the applied science teacher could work with students on basic principles of electricity (volts, amps, ohms, watts, etc.), and the applied mathematics teacher could help students with metric units (micro, mili, kilo, mega, etc.) and in solving problems using Ohm's law.

Review:

Ask students review questions such as the following:

1. What is the proper use of a DMM on voltage, amperage, and ohm settings?
2. How should you connect the meter for voltage readings?
3. How much voltage is dropped before returning to the battery?
4. What does an infinite reading on the Ohm's scale mean?

Application:

1. Have students practice testing voltage drops across light bulbs or resistors using training modules. Change resistance by using opens and shorts.
2. Assign students a vehicle, and have them check for voltage drops across the accessible wiring connections on the engine compartment.
3. Give students a battery and a roll of wire with a load (light bulb) at one end, and have them check voltage drop in the length of wire.
4. Set up vehicle with headlights on and engine at 2,000 RPM, and have students use DMM to check for AC voltage at battery (max .4 volts AC).
5. Ask for a student volunteer. Strap pennies to the back of the student's hands with rubber bands, hook DMM to both pennies, and ask another student to identify the resistance reading (ohms). Ask student questions, while second student monitors changes in resistance readings. (This works as primitive lie detector test.)
6. Have students check current draw on an engine cooling fan.

Evaluation:

√ Each student will obtain and interpret DMM readings. His/her performance will be evaluated using a copy of the performance checklist for Competencies 6.1.3/8.2.5.

Competency 6.1.3: Check voltage and voltage drop in electrical/electronic circuits using a digital multimeter (DMM); determine needed repairs
Competency 8.2.5: Obtain and interpret digital multimeter (DMM) readings

Performance Checklist

In obtaining and interpreting DMM readings, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Connected DMM correctly to component being tested	☐	☐	☐	☐	☐
5. Measured each of the following using the DMM in accordance with standard procedure:					
a. Voltage	☐	☐	☐	☐	☐
b. Amperage/current	☐	☐	☐	☐	☐
c. Resistance/ohms	☐	☐	☐	☐	☐
d. Voltage drop	☐	☐	☐	☐	☐
6. Obtained accurate readings	☐	☐	☐	☐	☐
7. Compared values obtained to known "good" values	☐	☐	☐	☐	☐
8. Interpreted readings accurately	☐	☐	☐	☐	☐
9. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 8: Engine Performance

Subunit 8.2: Computerized Engine Controls Diagnosis and Repair

Competency 8.2.7: Locate and interpret vehicle and major component identification numbers (VIN, vehicle certification labels and calibration decals)

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Locate and interpret vehicle and major component identification numbers
Criteria:	In accordance with the criteria in the checklist for Competency 8.2.7

Introduction:

General Introductory Techniques: Share personal experiences you have had when locating and interpreting vehicle and major component identification numbers in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Why is it so important to be able to locate vehicle labels (e.g., VIN, vehicle certification labels, and calibration decals)?
2. What kinds of information can be found on these labels?

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Sample Labels	2. Coding systems Location of information on the labels
3. Label Locations	3. Common locations and those specific to manufacturer: • Under hood locations • Door jamb or door frame locations • Trunk lid locations • Trim panel or glove box locations

Presentation Outline	Steps to Cover/Key Points to Make
4. Interpreting Label Information	4. Use of reference materials (e.g., service manuals) Information provided by different label types: • Emission certifications • Tune-up specifications • Vehicle Production Option Codes (for parts ordering, etc.) • Type of restraint system used • Gross Vehicle Weight specifications • Tire size and pressure specifications • Spare tire changing/storing information • Vehicle serial numbers and assembly locations • Vehicle build dates (helpful when ordering parts and the manufacturer has changed something)

> ***Note:*** The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.
>
> For example, the applied communications teacher could assist students with service manual interpretation and use.

Review:

Ask students review questions such as the following:

1. What does the eighth digit of the VIN designate?
2. What does the calibration code mean?

Application:

1. Give students sheets with different labels, and have them interpret the codes.
2. Give students sheets with questions to answer by locating and interpreting the labels on specific vehicles.

Evaluation:

√ Each student will locate and interpret vehicle and major component identification numbers. His/her performance will be evaluated using a copy of the performance checklist for Competency 8.2.7.

Competency 8.2.7: Locate and interpret vehicle and major component identification numbers (VIN, vehicle certification labels and calibration decals)

Performance Checklist

In locating and interpreting vehicle and major component identification numbers, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Located vehicle/major component identification labels (VIN, vehicle certification labels, calibration decals)	☐	☐	☐	☐	☐
5. Correctly interpreted information from vehicle/major component identification labels	☐	☐	☐	☐	☐
6. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name______________________________________**Date**_____________

Units 6/8: Electrical/Electronic Systems/Engine Performance

Subunits 6.1/8.2: General Electrical System Diagnosis/Computerized Engine Controls Diagnosis and Repair

Competency 6.1.6: Find shorts, grounds, opens, and resistance problems in electrical/electronic circuits; determine needed repairs

Competency 8.2.8: Inspect and test power and ground circuits and connections; service or replace as needed

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Find shorts, grounds, opens, and resistance problems in electrical/electronic circuits, and determine needed repairs
Criteria:	In accordance with the criteria in the checklist for Competencies 6.1.6/8.2.8

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when finding problems in electrical/electronic circuits and determining needed repairs. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Have students lead a review of electricity principles, use of Ohm's law, and proper use of diagnostic equipment (DMM, ammeter) and wiring diagrams.

2. If you can't find the electrical problem, you can't fix it. Replacing all parts in an electrical circuit is an expensive way to repair electrical circuits—and illegal, too. A good electrical diagnostician is always in demand in this industry.

3. To accurately test a circuit, you need to check the power and ground system in order to reduce incorrect diagnoses. Poor grounds can cause circuit and component failure. Poor power supplies can cause improper circuit operation.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Note: Earlier competencies in Subunit 6.1 focused on the skills and tools used in diagnosis. This lesson should focus on putting these skills together and selecting the right tools to use.

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical References	2. Refer to TSBs and schematics for system being tested in order to understand the fault and the system in which the fault is occurring.
3. Methods for Diagnosing a Circuit	3. Check source voltage. Check fuses. Check for power at component. Check for ground at component.
4. Using Test Light	4. Types of test lights (circuit-powered, self-powered) Procedure for using test light to check circuit for power, including— ◆ One end of test light must be hooked up to a known good ground, with the other end used to probe for power source. Procedure for using test light to check circuit for ground, including— ◆ One end of test light must be hooked up to a known good power, with the other end used to probe for ground. Procedure for using test light to find shorts ***Caution:*** Don't use a test light that has a high amp draw on computer circuits as this could damage the computer.

Presentation Outline	Steps to Cover/Key Points to Make
5. Checking a Power Supply Circuit	5. Tester on VOLT setting Negative to ground Positive to circuit being tested Should show system voltage (5v, 12v, etc.)
6. Checking a Ground Circuit	6. Tester on VOLT setting Negative to ground Positive to circuit being tested Should show 0v or below 500mv
7. Diagnosing Problems *One option would be to set up circuits with shorts, grounds, opens, and resistance problems and use these as examples as you walk students through the diagnostic process.*	7. Diagnostic process: • Select and use appropriate test equipment. • Refer to appropriate wiring diagrams. • Use Ohm's law. • Isolate the problem using separating connectors. • Identify problem.
8. Determining Needed Repairs	8. Using diagnostic information gathered, refer to service manuals to identify needed repairs.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

Throughout Unit 6, the applied science teacher could work with students on basic principles of electricity (volts, amps, ohms, watts, etc.), and the applied mathematics teacher could help students in solving problems using Ohm's law.

Review:

Ask students review questions such as the following:

1. Do corrosion or poor connections cause high amps to blow fuses?
2. Is it hard to find a short to ground? Why or why not?
3. What is the rule of thumb for an acceptable ground circuit voltage drop?
4. If you get a high voltage reading (above 500mv) when testing the grounds, what might this indicate?

Application:

1. Build circuit problems into training aids, and have students use wiring diagrams to diagnose the problems.

2. Use a wiring diagram to indicate a vehicle fault (perhaps an open on a parking lamp), and have students indicate what test light and/or DMM readings they think this fault would produce. Then have students introduce the fault into the vehicle and determine the actual reading it produces.

3. Give students a wiring diagram and information about a vehicle with an open on a circuit, and have them indicate the procedures and tests they would use to find where the potential faults could be.

Evaluation:

√ Each student will find shorts, grounds, opens, and resistance problems in electrical/electronic circuits and determine needed repairs. His/her performance will be evaluated using a copy of the performance checklist for Competencies 6.1.6/8.2.8.

Competency 6.1.6: Find shorts, grounds, opens, and resistance problems in electrical/electronic circuits; determine needed repairs
Competency 8.2.8: Inspect and test power and ground circuits and connections; service or replace as needed

Performance Checklist

In finding problems in electrical/electronic circuits and determining needed repairs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
3. Selected correct diagnostic tool(s) for checking circuit	☐	☐	☐	☐	☐
4. Attached test equipment in accordance with established procedures	☐	☐	☐	☐	☐
5. Obtained accurate results from all tests	☐	☐	☐	☐	☐
6. Used wiring diagrams to aid diagnosis	☐	☐	☐	☐	☐
7. Correctly interpreted wiring diagrams	☐	☐	☐	☐	☐
8. Identified shorts, grounds, opens, and resistance problems	☐	☐	☐	☐	☐
9. Determined needed repair	☐	☐	☐	☐	☐
10. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competencies 8.3.1/8.3.2: Diagnose no-starting, driveability, and emissions problems on vehicles with electronic ignition (distributorless) and distributor ignition (DI) systems; determine needed repairs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Diagnose no-starting, driveability, and emissions problems; and determine needed repairs
Criteria:	In accordance with the criteria in the checklist for Competencies 8.3.1/8.3.2

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when diagnosing no-starting, driveability, and emissions problems on vehicles with electronic ignition (distributorless) and distributor ignition (DI) systems and determining needed repairs. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. The old days are gone. New cars don't have distributors. Nevertheless, you will still see cars with distributors so you need to learn to diagnose and fix cars both with and without distributors.

2. Auto makers moved to distributorless ignitions because they have fewer moving parts, greater efficiency, and more control of engine performance.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Review of Engine Performance Principles	2. Essentials for efficient combustion: • Proper amount of fuel and clean air in cylinder • Correct spark voltage delivered to correct cylinder at right time • Maintenance of specified engine temperature with a well-maintained cooling system Factors involved in driveability and emissions: • Proper fuel/air ratio (14.7:1 is ideal for efficient combustion, good fuel economy, and clean exhaust emissions) • All emission control assemblies installed and operating correctly • Engine cooling and lubrication systems properly maintained

Presentation Outline	Steps to Cover/Key Points to Make
3. Performing Visual Inspection	3. Visually check all electrical and vacuum connections. Look for signs of damage, tampering: ◆ Cut, unrepaired, or frayed wiring ◆ Damaged, burnt, cut, or broken spark plug secondary leads ◆ Disconnected, cut, or melted vacuum lines ◆ Disconnected, broken, or bypassed thermal vacuum switches (TVS) Repair as needed.
4. Checking for Presence of Spark	4. Standard procedure for checking for spark Importance of safety concerns with DI systems (potential injury from spark)
5. Determining Needed Repairs	5. Using diagnostic information gathered, refer to service manuals to identify needed repairs.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could help students understand how different fuel/air ratios affect combustion, fuel economy, and exhaust emissions.

Review:

Ask students review questions such as the following:

1. What are the differences between distributorless and conventional ignition?
2. Why is safety a key factor in working with DI systems?

Application:

1. Give students a teacher-prepared diagram of an ignition system, and have them label the primary components (coils, modules, pick up, control unit) and secondary components (cap, rotor, wires, plugs).
2. Disable one or more vehicles, and have pairs of students work together to diagnose the cause of the no-starting problem.

Evaluation:

√ Each student will diagnose no-starting, driveability, and emissions problems; and determine needed repairs. His/her performance will be evaluated using a copy of the performance checklist for Competencies 8.3.1/8.3.2.

Competencies 8.3.1/8.3.2: Diagnose no-starting, driveability, and emissions problems on vehicles with electronic ignition (distributorless) and distributor ignition (DI) systems; determine needed repairs

Performance Checklist

In diagnosing no-starting, driveability, and emissions problems and determining needed repairs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Secured needed information through customer interview	☐	☐	☐	☐	☐
5. Performed complete visual inspection	☐	☐	☐	☐	☐
6. Checked for presence of spark in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
7. Determined needed repairs	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**_____________

Unit 8: Engine Performance

Subunit 8.3: Ignition System Diagnosis and Repair

Competency 8.3.7: Check and adjust (where applicable) ignition system timing and timing advance/retard

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Check and adjust (where applicable) ignition system timing and timing advance/retard
Criteria:	In accordance with the criteria in the checklist for Competency 8.3.7

Introduction:

General Introductory Techniques: Share personal experiences you have had when checking and adjusting ignition system timing and timing advance/retard in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Ignition timing must be accurate, or engine performance, fuel economy, and exhaust emission control will suffer. The spark must reach the correct spark plug at precisely the right moment for complete combustion to occur in all cylinders. If the advance/retard mechanisms are not good, as RPMs increase, the spark cannot leap up, and the engine will run less efficiently.

2. When you set or adjust ignition timing, it is important to follow the manufacturer's instructions and set timing to manufacturer's specifications.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Timing Equipment	2. Timing light: ◆ A strobe lamp connected to the #1 plug wire will "flash" each time the plug fires. ◆ The "flash" beam is directed at a *timing mark* to read the ignition timing. Timing meter: ◆ Used as a "magnetic pickup" method at the engine crankshaft ◆ Usually considered a more accurate method for ignition timing
3. Preparation	3. Obtain ignition timing specifications from service manual. Locate engine timing marks. Connect timing light according to manufacturer's instructions. Connect tachometer to engine. Follow directions on emission label under hood, or consult service manual. Always connect exhaust hose to a running vehicle.

Presentation Outline	Steps to Cover/Key Points to Make
4. Setting or Adjusting Ignition Timing	4. Follow manufacture's instructions. Aim strobe lamp at timing marks. Adjust distributor, if necessary, to set to specification. Reassemble any components.
5. Testing Centrifugal Advance Mechanism	5. Disconnect distributor vacuum advance hose. Aim timing lamp to timing marks. Note reading. Watch the beam on the marks. Run the engine gradually from idle up to about 1,800-2,000 RPM. Note timing. Compare advance reading amount to specifications. If timing advanced smoothly as RPM increased, it's okay. Slow RPM down to idle. Note reading. If it returned to base reading, retard is good.
6. Testing Vacuum Advance	6. Install timing light. Run engine at idle. Disconnect distributor's vacuum/ advance hose. Connect hand-held vacuum pump to vacuum advance. Apply approximately 15"Hg of vacuum to distributor, and point timing light at timing marks. Timing should advance smoothly as the amount of vacuum is increased.
7. Determining Needed Repairs	7. Document all readings. Using diagnostic information gathered, refer to service manuals to identify needed repairs.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could explain to students how a strobe light operates.

Review:

Ask students review questions such as the following:

1. Where are timing marks usually located?
2. Why should the vacuum line be disconnected prior to performing a centrifugal advance test?

Application:

1. Have students practice adjusting ignition timing on no fewer than two vehicles.
2. Assign students to teams of two, and have each team perform centrifugal and vacuum advance tests on a vehicle, document the results, and report its findings and repair recommendations to the instructor.

Evaluation:

√ Each student will check and adjust (where applicable) ignition system timing and timing advance/retard. His/her performance will be evaluated using a copy of the performance checklist for Competency 8.3.7.

Competency 8.3.7: Check and adjust (where applicable) ignition system timing and timing advance/retard

Performance Checklist

In checking and adjusting ignition system timing and timing advance/retard, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Identified manufacturer's specifications	☐	☐	☐	☐	☐
5. Located engine timing marks	☐	☐	☐	☐	☐
6. Connected timing light to engine	☐	☐	☐	☐	☐
7. Checked/adjusted ignition timing in accordance with manufacturer's instructions	☐	☐	☐	☐	☐
8. Tested distributor centrifugal advance system	☐	☐	☐	☐	☐
9. Tested distributor vacuum advance system	☐	☐	☐	☐	☐
10. Documented test results	☐	☐	☐	☐	☐
11. Determined needed repairs	☐	☐	☐	☐	☐
12. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 8: Engine Performance

Subunit 8.4: Fuel, Air Induction, and Exhaust Systems Diagnosis and Repair

Competency 8.4.2:	Diagnose hot or cold no-starting, hard starting, poor driveability, incorrect idle speed, poor idle, flooding, hesitation, surging, engine misfire, power loss, stalling, poor mileage, dieseling, and emissions problems on vehicles with injection-type fuel systems; determine needed action

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Diagnose problems on vehicles with injection-type fuel systems, and determine needed action
Criteria:	In accordance with the criteria in the checklist for Competency 8.4.2

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when diagnosing problems on vehicles with injection-type fuel systems and determining needed action. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. To diagnose nearly any type of driveability concern correctly, there is a standard procedure that may be followed.

2. As you carry out this procedure, you also need to ask, is the problem common or non-common? Does the problem affect only one cylinder, or does it affect all cylinders together?

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Performing Visual Inspection	2. Check all electrical, vacuum, and fuel connections. Repair as needed.
3. Checking Data	3. Check diagnostic trouble codes to determine whether there is a fault in the system. Check scan data, if available, in accordance with manufacturer's guidelines.
4. Determining Extent of Problem	4. To determine whether the problem is common to one or two cylinders or affects the entire engine, ask questions such as the following: • Is one cylinder misfiring? • Is the engine rich or lean? • Is the ignition timing correct?
5. Checking Fuel & Ignition Systems	5. Importance of following manufacturer's specifications General procedures for checking the following: • Fuel pressure and volume • Ignition system, primary and secondary systems

Presentation Outline	Steps to Cover/Key Points to Make
6. Identifying Problem Area	6. Perform more specific testing as required for complete diagnosis.
7. Determining Needed Repairs	7. Using diagnostic information gathered, refer to service manuals to identify needed repairs.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied communications teacher could work with students on reading as a problem-solving strategy.

Review:

Ask students review questions such as the following:

1. Why is a logical procedure necessary in diagnosing these problems?
2. Why is important to determine whether a problem is common or non-common?

Application:

1. Disable one or more vehicles, and have students diagnose the problem(s), provide written documentation of the data, and make repair recommendations.
2. Have students prepare a table listing each of the conditions named in the competency statement and then use the shop manual to identify and list possible causes of each condition.

Evaluation:

√ Each student will diagnose problems on vehicles with injection-type fuel systems and determine needed action. His/her performance will be evaluated using a copy of the performance checklist for Competency 8.4.2.

Competency 8.4.2: Diagnose hot or cold no-starting, hard starting, poor driveability, incorrect idle speed, poor idle, flooding, hesitation, surging, engine misfire, power loss, stalling, poor mileage, dieseling, and emissions problems on vehicles with injection-type fuel systems; determine needed action

Performance Checklist

In diagnosing problems on vehicles with injection-type fuel systems and determining needed action, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Secured needed information through customer interview	☐	☐	☐	☐	☐
5. Performed complete visual inspection	☐	☐	☐	☐	☐
6. Checked diagnostic trouble codes and scan data	☐	☐	☐	☐	☐
7. Accurately determined extent of problem	☐	☐	☐	☐	☐
8. Checked fuel pressure and volume in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
9. Checked ignition system in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
10. Correctly identified problem area	☐	☐	☐	☐	☐
11. Performed more specific testing if required	☐	☐	☐	☐	☐
12. Determined needed repairs	☐	☐	☐	☐	☐
13. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 8: Engine Performance

Subunit 8.4: Fuel, Air Induction, and Exhaust Systems Diagnosis and Repair

Competency 8.4.6: Replace fuel filters

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Replace fuel filters
Criteria:	In accordance with the criteria in the checklist for Competency 8.4.6

Introduction:

General Introductory Techniques: Share personal experiences you have had when replacing fuel filters in the auto tech shop. Show videos available from manufacturers that demonstrate the steps in this process.

Competency-Specific Information:

1. For clean fuel to reach the necessary engine components, fuel filter replacement is essential. A manufacturer's service interval guide will let you know when it is time for the change.

2. In order to correctly replace the fuel filter assembly, you must follow manufacturer's instructions. Remember, fuel is a consistent fire and safety hazard.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Fuel is under pressure and can cause injury from spray if pressure is not relieved.
3. Replacement Procedure	3. Locate fuel filter (refer to shop manual). Disconnect power to fuel pump in accordance with manufacturer's specifications. Start vehicle; let run for a few seconds until fuel pressure is relieved. Crank engine over for 5 seconds to relieve any remaining pressure. Remove lines from filter (if applicable); watch for fuel spilling from lines and filter. Clean up any spilled fuel immediately; fuel vapor and liquid are hazardous. Install new filter, ensuring that all lines are properly secured. Reconnect power to fuel pump in accordance with manufacturer's specifications. Start engine. Check for leaks; repair any leaks immediately. Clean up any remaining spilled fuel; liquid fuel can be a hazard (can cause falls).

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher can work with students on pressure relationships.

Review:

Ask students review questions such as the following:

1. Why must you relieve the fuel pressure prior to removing the fuel filter?
2. Why is a leaking filter a safety hazard?

Application:

1. Have students practice replacing the fuel filter on a vehicle that has a gasoline engine.
2. Have students practice replacing the fuel filter on a vehicle that has a diesel engine.
3. Ask students to compare the replacement procedures for the two types of engines. Similarities? Differences?

Evaluation:

√ Each student will replace fuel filters. His/her performance will be evaluated using a copy of the performance checklist for Competency 8.4.6.

Competency 8.4.6: Replace fuel filters

Performance Checklist

In replacing fuel filters, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Determined fuel filter location and type	☐	☐	☐	☐	☐
5. Selected correct fuel filter type	☐	☐	☐	☐	☐
6. Disconnected power to fuel pump in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
7. Relieved all fuel pressure	☐	☐	☐	☐	☐
8. Replaced fuel filter in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
9. Ensured that all lines were properly secured	☐	☐	☐	☐	☐
10. Cleaned up any fuel spills immediately	☐	☐	☐	☐	☐
11. Performed final visual check for leaks	☐	☐	☐	☐	☐
12. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

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Unit 8: Engine Performance

Subunit 8.5: Emissions Control Systems Diagnosis and Repair: Positive Crankcase Ventilation

Competency 8.5.1: Diagnose oil leaks, emissions and driveability problems resulting from failure of the positive crankcase ventilation (PCV) system

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Diagnose problems resulting from failure of the PCV system
Criteria:	In accordance with the criteria in the checklist for Competency 8.5.1

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when diagnosing problems resulting from failure of the PCV system. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. The PCV system was first introduced around 1963.
2. Show PCV valve to class.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. PCV System Operation	2. How the valve operates: • At idle or normal acceleration, the PCV is open and allows maximum flow of blowby gases due to the high manifold vacuum produced. Flow is through PCV valve. • At high engine load or heavy acceleration, the PCV closes, and pressure causes the blowby gases in the crankcase to be drawn into the intake manifold through the fresh air inlet.
3. PCV System Purposes	3. To lower hydrocarbons To protect engine against backfire To improve oil life

Presentation Outline	Steps to Cover/Key Points to Make
4. Testing PCV System	4. Testing procedure (in accordance with manufacturer's specifications) Proper vacuum Special tester Diagnosis of problem Manual PCV checking method: ◆ Inspect all system hoses and valve for blockage, cracks, holes, and breaks. ◆ Run engine. ◆ Remove PCV from valve cover or intake manifold, and plug it with your thumb. ◆ You should feel a vacuum. If not, the hose is plugged or the PCV valve is bad.
5. Diagnosing Problem	5. Possible causes of PCV failure: ◆ Restricted vacuum hose ◆ Excessive blowby ◆ Valve malfunction

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could work with students on vacuum-pressure relationships.

Review:

Ask students review questions such as the following:

1. True or False: The PCV valve is held open by vacuum.
2. If there is oil in the air cleaner, does this indicate that the valve is stuck open or closed?

Application:

1. Divide students into teams, and have each group develop a table describing PCV valve operation under various given driving conditions.
2. As students practice diagnosing problems resulting from PCV failure, quiz them individually on the process (e.g., ask them to explain how to determine whether valve is malfunctioning).

Evaluation:

√ Each student will diagnose problems resulting from failure of the PCV system. His/her performance will be evaluated using a copy of the performance checklist for Competency 8.5.1.

Competency 8.5.1: Diagnose oil leaks, emissions and driveability problems resulting from failure of the positive crankcase ventilation (PCV) system

Performance Checklist

In diagnosing problems resulting from failure of the PCV system, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct test equipment and tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Checked PCV valve for proper operation (e.g., proper vacuum) per manufacturer's specifications	☐	☐	☐	☐	☐
5. Performed complete visual inspection, looking for leaks and/or loose, cracked, or pinched vacuum hose	☐	☐	☐	☐	☐
6. Checked engine emissions in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
7. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 8: Engine Performance

Subunit 8.6: Emissions Control Systems Diagnosis and Repair: Exhaust Gas Recirculation

Competency 8.6.1: Diagnose emissions and driveability problems caused by failure of the exhaust gas recirculation (EGR) system

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Diagnose problems caused by failure of the EGR system
Criteria:	In accordance with the criteria in the checklist for Competency 8.6.1

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when diagnosing problems caused by failure of the EGR system. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Describe examples of how the EGR system affects engine operation.
2. Show an EGR valve to the class.
3. Describe how NO_x is generated in combustion chamber.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Location of EGR Valves	2. General location
3. Operation of EGR Valves	3. The valve is controlled by ported vacuum and/or computer, depending on the manufacturer. Purposes of valve: • Reduces combustion chamber temperatures below 2500° to control NO_x formation • Helps to reduce detonation/pre-ignition problems
4. Testing the System	4. Ways of testing EGR operation: • Use of tachometer • Use of vacuum pump
5. Diagnosing Causes of EGR Failure	5. Possible causes of EGR failure: • Vacuum leaks • Carbon buildup • Valve failure
6. Rough Idle/Detonation	6. If EGR is held open, this can cause rough idle or stalling. If EGR remains closed, this can cause detonation.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could work with students on creating, standardizing, and documenting procedures.

Review:

Ask students review questions such as the following:

1. What causes oxides of nitrogen (NO_x) to form?
2. How could recirculating the exhaust gases help prevent the formation of NO_x?
3. True or False: Engine detonation could be caused by a blocked EGR exhaust passage.
4. True or False: Some EGR systems are controlled by manifold vacuum.

Application:

1. Role-play a customer with students to improve their diagnostic skills. Give them a series of poor driveability symptoms (e.g., hesitation on acceleration), and have them determine the cause of each symptom.
2. As students practice diagnosing problems caused by the EGR system, quiz them individually on the process (e.g., ask them to describe how specific problems affect driveability).

Evaluation:

√ Each student will diagnose problems caused by failure of the EGR system. His/her performance will be evaluated using a copy of the performance checklist for Competency 8.6.1.

Competency 8.6.1: Diagnose emissions and driveability problems caused by failure of the exhaust gas recirculation (EGR) system

Performance Checklist

In diagnosing problems caused by failure of the EGR system, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct test equipment and tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Secured needed information through customer interview	☐	☐	☐	☐	☐
5. Checked EGR operation in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
6. Performed complete visual inspection, looking for loose, cracked, pinched, or plugged vacuum hose, wiring, and connectors	☐	☐	☐	☐	☐
7. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Units 1/8: Engine Repair/Engine Performance

Subunits 1.2/8.11: Cylinder Head and Valve Train Diagnosis and Repair/
Engine Related Service

Competencies 1.2.13/8.11.1: Adjust valves on engines with mechanical or hydraulic lifters

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Adjust valves on engines with mechanical and hydraulic lifters
Criteria:	In accordance with the criteria in the checklist for Competencies 1.2.13/8.11.1

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when adjusting valves on engines with mechanical and hydraulic lifters. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Valves must be adjusted periodically as part of a vehicle's maintenance schedule or after repairs have been made to the cylinder head or valve train areas of an engine.

2. Explain why it is essential to the operation of the engine that the valves be adjusted with precision in accordance with the manufacturer's specific procedures and specifications.

3. Briefly discuss the difference between valves with mechanical and hydraulic lifters.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Importance of Timing	2. Valves and pistons ***must*** be synchronized for proper engine operation.
3. Valve Noise	3. Possible causes: - Faulty adjustment - Worn rocker arms - Bent pushrod or bad camshaft
4. Preparation	4. Warm engine. Remove valve covers. Install splatter shields.

Presentation Outline	Steps to Cover/Key Points to Make
5. Adjusting Valves with Mechanical Lifters	5. Mechanical lifters usually require adjustment in accordance with the vehicle maintenance schedule. Manufacturer's procedures should be followed to the letter, using correct tools and specifications. General procedure: ◆ Start engine. ◆ Use feeler gauge to determine the clearance between the rocker arm and valve stem. ◆ Adjust clearance in accordance with manufacturer's specifications. ***Note:*** On some vehicles, the valve/tappet cover gasket is ***reusable***.
6. Adjusting Valves with Hydraulic Lifters	6. Hydraulic lifters usually require adjustment only as result of a repair (they were developed to ***lessen*** maintenance costs and noise). Manufacturer's procedures should be followed to the letter, using correct tools and specifications. General procedure: ◆ Start engine. ◆ Loosen rocker arms until they clatter. ◆ Tighten the rocker arms, one at a time, in accordance with manufacturer's specifications. ***Note:*** On some vehicles, the valve/tappet/rocker cover gasket is ***reusable***.
7. Consequences of Incorrect Adjustment	7. Too tight: ◆ Miss in motor ◆ Valves not closing totally Too loose: ◆ Noise in motor ◆ Valves not opening totally
8. Maintaining Clean Work Area	8. Clean all spilled oil, gasket materials, and debris out of the engine area.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could work with students on cam timing and number of degrees (duration) valve is open or closed..

Review:

Ask students review questions such as the following:

1. Why is the hydraulic valve more popular than the mechanical valve with most manufacturers?
2. If a valve is out of adjustment, what are the symptoms?
3. Why is proper clearance of valve train components important to efficient engine operation?
4. Why do hydraulic lifters not need to be adjusted ***periodically*** as mechanical lifters do?
5. Which type of valve is adjusted using a feeler gauge: mechanical or hydraulic?
6. True or False: If there is excessive valve lash, it means that the valve was adjusted too tight.

Application:

1. Have students prepare a table to guide diagnosis in the shop. For example, in one column, they could list all possible symptoms resulting from a valve that is adjusted too tight. In another column, they could list all possible causes of valve noise.
2. Have students prepare a procedure sheet for adjusting mechanical valves on a given vehicle (as specified by instructor) that can be used to guide student practice in the lab. This can be done on an individual, small-group, or whole-class basis.
3. Have students prepare a procedure sheet for adjusting hydraulic valves on a given vehicle (as specified by instructor) that can be used to guide student practice in the lab. This can be done on an individual, small-group, or whole-class basis.

Evaluation:

√ Each student will adjust valves on engines with mechanical and hydraulic lifters. His/her performance will be evaluated using a copy of the performance checklist for Competencies 1.2.13/8.11.1.

Competencies 1.2.13/8.11.1: Adjust valves on engines with mechanical or hydraulic lifters

Performance Checklist

In adjusting valves on engines with mechanical and hydraulic lifters, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Followed preparation procedures appropriate for type of valve	☐	☐	☐	☐	☐
5. Adjusted mechanical/hydraulic lifters in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
6. Performed visual inspection of hydraulic lifters:					
a. Checked fluid level	☐	☐	☐	☐	☐
b. Checked condition of surfaces	☐	☐	☐	☐	☐
c. Replaced valve cover gasket if needed	☐	☐	☐	☐	☐
d. Checked for leaks	☐	☐	☐	☐	☐
e. Checked tightness of fasteners/fittings	☐	☐	☐	☐	☐
7. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name______________________________________**Date**______________

Unit 8: Engine Performance

Subunit 8.11: Engine Related Service

Competency 8.11.2: Verify correct camshaft timing; determine needed action

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Verify correct camshaft timing, and determine needed action
Criteria:	In accordance with the criteria in the checklist for Competency 8.11.2

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when verifying correct camshaft timing and determining needed action. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Discuss shape of cam (wedge-shaped) and its function (to open and close items—like engine valves—as it rotates).

2. Discuss different types of cam drives (e.g., gear-to-gear, chain-, and belt-driven).

3. If a cam is out of time, the valves could hit the pistons and cause engine damage. Wear in timing chain or belt means the valve doesn't open and close exactly as desired, which causes a loss of engine efficiency. Thus, verifying correct camshaft timing is critical.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Definitions of Key Terms	2. Valve overlap Duration Lift Backlash
3. Timing Marks	3. Examples (handouts/transparencies) of a variety of timing methods used by different manufacturers (see service or tune-up manuals)
4. Diagnostic Procedures	4. Method for identifying excessive backlash in camshaft Procedures for determining whether any of the following components need to be replaced: • Cam gears (e.g., Is there evidence of excessive wear?) • Chain (e.g., Is it worn and stretched past deflection permitted?) • Belts (e.g., Is there evidence of peeling, cracks, missing teeth, exposed rubber?) • Timing belt sprocket (e.g., Are there any gaps on the teeth?)

Presentation Outline	Steps to Cover/Key Points to Make
5. Determining Needed Action	5. Using diagnostic information gathered, refer to service manuals to identify needed action. For example, check manufacturer's specifications for amount of wear permissible in chain or between gear teeth.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could work with students on measuring time in crankshaft movement by degrees of a circle.

Review:

Ask students review questions such as the following:

1. What engine components need to be removed in order to visually inspect the cam-crank timing marks on a V-8 engine?
2. Most manufacturers recommend that the timing belt be replaced after how many miles?

Application:

1. Give students a teacher-prepared handout with diagrams of aligned and misaligned timing marks, and have them circle the misaligned marks.
2. Have students practice changing the cam timing on a variety of different engines.

Evaluation:

√ Each student will verify correct camshaft timing and determine needed action. His/her performance will be evaluated using a copy of the performance checklist for Competency 8.11.2.

Competency 8.11.2: Verify correct camshaft timing; determine needed action

Performance Checklist

In verifying correct camshaft timing and determining needed action, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Rotated engine crankshaft to position: #1 cylinder at top dead center (TDC)	☐	☐	☐	☐	☐
5. Verified correct camshaft timing	☐	☐	☐	☐	☐
6. Identified any timing belt or chain wear	☐	☐	☐	☐	☐
7. Determined action needed	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name_______________________________________**Date**_____________

Units 1/7/8: **Engine Repair/Heating and Air Conditioning/Engine Performance**

Subunits 1.4/7.4./8.11: Lubrication and Cooling Systems Diagnosis and Repair/
Heating and Engine Cooling Systems Diagnosis and Repair/
Engine Related Service

Competency 1.4.3	Perform cooling system tests (pressure, combustion, leakage, and temperature); determine needed repairs
Competency 7.4.2	Perform cooling system, cap, and recovery system tests (pressure, combustion, leakage, and temperature); determine needed repairs
Competency 8.11.3	Verify engine operating temperature; determine needed action
Competency 8.11.4:	Perform cooling system pressure tests; check coolant condition; inspect and test radiator, pressure cap, coolant recovery tank, and hoses; service or replace as needed

Competency Development Guide

Objective:

Condition: Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines

Behavior: Perform cooling system tests, and determine needed repairs

Criteria: In accordance with the criteria in the checklist for Competencies 1.4.3/7.4.2/8.11.3/8.11.4

Introduction:

General Introductory Techniques: Share personal experiences you have had in the auto tech shop when performing cooling system tests and determining needed repairs. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. A cooling system is very important to engine performance and to the engine's service life.

2. Without proper cooling, an engine can suffer severe damage in just a manner of minutes.

3. Antifreeze is important in warm weather as well as cold. In warm weather, it provides improved cooling.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Be always aware of moving parts (e.g., fan blades, pulleys, belts). Radiator coolant is under pressure in a running engine, and it is ***hot***. If you try to take off the radiator cap while the engine is hot, the release of pressurized liquid can make the coolant boil and expand. If allowed to spurt out of the radiator filler neck area, boiling coolant can cause ***severe burns***.
3. System Components	3. Characteristics/operation of the following: • Radiator • Thermostat • Heater core • Hoses • Pump • Radiator pressure cap Examples of worn components Problems that might occur as a result of the wear

Presentation Outline	Steps to Cover/Key Points to Make
4. Performing Pressure Test	4. This test is used to quickly locate the source of coolant leakages. The *pressure tester* is a hand-operated air pump, which forces compressed air onto the coolant. General procedure: ◆ Remove radiator pressure cap (with car at normal operating temperature). ◆ Check coolant level. ◆ Use antifreeze hydrometer to test freeze protection level of coolant. ◆ Wipe inside of filler neck; check for damage inside sealing seat. ◆ Inspect overflow tube for dents, kinks, or obstructions. ◆ Inspect cams on outside of filler neck; reform any bent cams. ◆ Install the tester on the radiator filler neck, in place of the radiator cap. ◆ Using manufacturer's specifications, pump the tester until the gauge on the tester reaches the correct pressure (generally in the 14–16 psi or 96 kPa range). ***Caution:*** Do not over-pressurize the system beyond the specifications because you could cause a component to rupture. The gauge pressure should hold for at least 3 minutes steady. Document any drop of pressure seen. Interpret reading: ◆ If pressure holds ◆ If pressure drops quickly ◆ If pressure drops slowly Visually inspect all parts (hose fittings, clamps, radiator, water pump, intake manifold, cylinder head-to-block contacts, core plugs, heater core, etc.) for coolant leakage.

Presentation Outline	Steps to Cover/Key Points to Make
5. Performing Combustion Leak Test	5. This test is used to check for the presence of combustion chamber gases in the coolant. It should be performed when you have signs that point to a blown head gasket, cracked block, or cracked cylinder head (e.g., overheating, bubbles in coolant, a rise in coolant level when starting the engine). Put the *combustion leak tester* onto the radiator filler neck. Run the engine; then squeeze the tester bulb and release. This draws air through the test fluid. The test fluid (usually blue) will change to a yellow color if any combustion gases are leaking into the engine coolant. If the fluid stays blue, there is no combustion leak into the coolant. If a leak is indicated, short out the cylinders one at a time (***no longer than 15 seconds*** so as not to damage the catalytic converter). When the fluid does not change its color, you have found your leaking cylinder(s). Another method is to use an exhaust gas analyzer
6. Alternative Method for Performing Combustion Leak Test	6. This method uses an exhaust gas analyzer. Remove the radiator cap, and place a tail pipe probe over the neck. Accelerate the engine, and watch the hydrocarbon (HC) meter. If the meter reads, you have a leak.
7. Engine Overheating	7. Average operating temperature of an engine (around 230°) Importance of maintaining normal operating temperature in terms of engine operation and emissions Reasons why an engine may overheat

Presentation Outline	Steps to Cover/Key Points to Make
8. Performing Temperature Test	8. Remove radiator cap, and insert coolant thermometer into the neck. Run engine for up to 10 minutes, and note temperature while looking for coolant flow through radiator tubes. Temperature should be approximately 10%–15% above the thermostat rating of the engine. If the temperature is too high, locate causes of excess heat: • Feel upper radiator hose, checking for excessive temperature and/or gurgling. • Check coolant recovery tank for proper level. If the temperature is too low, suspect open thermostat, locked fan clutch, or electric fan running constantly.
9. Alternative Method for Performing Temperature Test	9. Tempsticks give a quick and fairly accurate diagnosis of thermostat operation without having to remove it. They are made of wax, one melting at about 188°F, the other at about 202°F. First, draw a short line on the thermostat housing with the 188° stick (one color). Using the 202° stick (which is another color), draw another line parallel to the 188° line and about 1/2" away. As the thermostat begins to open, the 188° line should melt. As the engine reaches operating temperature (thermostat fully open), the 202° line should melt.
10. Determining Needed Repairs	10. Using diagnostic information gathered, refer to service manuals to identify needed repairs.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could cover the composition of antifreeze, hazards related to handling antifreeze, and how coolant operates at different temperatures (230°F and 212°F).

Review:

Ask students review questions such as the following:

1. Describe safety concerns that apply to servicing/diagnosing the cooling system.
2. If you over-pressurize the radiator and cooling system during a pressure test, what could be the consequence?
3. When you hear the expression, "the engine's normal operating temperature," what range do you think that means?
4. What types of damage could occur as a result of an overheating engine?
5. What effect does one pound of pressure have on the boiling point of coolant?
6. True or False: The proper proportion of antifreeze to water is 20:40.

Application:

1. Give students a diagram of a cooling system, and have them indicate the potential trouble spots.
2. Have students use the textbook and service manuals to identify and define cooling system vocabulary terms. This can be done on an individual or small-group basis.
3. Give students a written case study describing a specific overheating problem, and have them troubleshoot that problem.
4. As students practice pressure testing the coolant system, quiz them individually on the process (e.g., ask them to explain how to locate leaks).
5. Create leaks in a coolant system (e.g., by loosening the clamps), and have students use the appropriate checks and tests to locate the problem.

Evaluation:

√ Each student will perform cooling system tests and determine needed repairs. His/her performance will be evaluated using a copy of the performance checklist for Competencies 1.4.3/7.4.2/8.11.3/8.11.4.

Competency 1.4.3	Perform cooling system tests (pressure, combustion, leakage, and temperature); determine needed repairs
Competency 7.4.2	Perform cooling system, cap, and recovery system tests (pressure, combustion, leakage, and temperature); determine needed repairs
Competency 8.11.3	Verify engine operating temperature; determine needed action
Competency 8.11.4:	Perform cooling system pressure tests; check coolant condition; inspect and test radiator, pressure cap, coolant recovery tank, and hoses; service or replace as needed

Performance Checklist

In performing cooling system tests and determining needed repairs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Selected appropriate equipment for performing cooling system pressure test	☐	☐	☐	☐	☐
5. Performed cooling system pressure test in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
6. Determined needed repairs	☐	☐	☐	☐	☐
7. Selected appropriate equipment for performing cooling system combustion leakage test	☐	☐	☐	☐	☐
8. Performed cooling system combustion leakage test in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
9. Determined needed repairs	☐	☐	☐	☐	☐
10. Selected appropriate equipment for performing cooling system temperature test	☐	☐	☐	☐	☐
11. Performed cooling system temperature tests in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
12. Determined needed repairs	☐	☐	☐	☐	☐
13. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Units 7/8: Heating and Air Conditioning/Engine Performance

Subunits 7.4/8.11: Heating and Engine Cooling Systems Diagnosis and Repair/ Engine Related Service

Competencies 7.4.4/8.11.5: Inspect and test thermostat, by-pass, and housing; replace as needed

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Inspect and test thermostat, by-pass, and housing; and replace them as needed
Criteria:	In accordance with the criteria in the checklist for Competencies 7.4.4/8.11.5

Introduction:

General Introductory Techniques: Share personal experiences you have had when inspecting, testing, and replacing thermostats, by-passes, and housings in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. The thermostat rating recommended by most of today's manufacturer's is 195°.
2. Discuss how engine temperature is controlled.
3. Explain how the operation of the thermostat affects fuel economy.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (9.1–9.4) Interpretation and verification of complaint (1.1.1/8.1.1) Accessing needed information using available references and resources (9.5) Selecting and using basic tools (9.6) Providing customer service (9.7)
2. Critical Safe Practices	2. Cautions regarding coolant temperature and pressure in cooling system Cautions regarding moving parts Exhaust removal system requirements
3. By-pass	3. Characteristics—usually a rubber hose attached between the water pump and engine block Purpose—provides for coolant flow through engine prior to thermostat opening Operation—allows coolant to flow between water pump and engine ***Note:*** Some engines have thermostats with a by-pass valve that shuts off the engine by-pass after warm-up so that all coolant is forced to flow into radiator.
4. Thermostat	4. Characteristics—starts to open within 3° of specified temperature; may have a subvalve and a main valve to help prevent hot spots at high temperatures Purpose—regulates engine temperature Operation—closed when engine is cold; opens when engine warms up Installation procedure (ensure that temperature pellet or side is installed toward the engine).

Presentation Outline	Steps to Cover/Key Points to Make
5. Testing Thermostat	5. Method 1 (with thermostat on vehicle): ◆ Vehicle engine must be cool when radiator cap is removed. ◆ Be sure vent tube is in vehicle exhaust. ◆ Run car to combustion temperature before performing test. ◆ Insert thermostat into coolant. ◆ If thermostat is operating properly, coolant will flow steadily inside the radiator, and temperature will not rise above temperature specified by manufacturer. Method 2 (off-car procedure): ◆ Heat a solution of antifreeze and water until the thermostat begins to open. ◆ Check the temperature of the solution. ◆ Compare actual temperature to temperature rating of the thermostat. Determine needed repairs.
6. Inspecting Housing	6. Inspect the housing for the following: ◆ Warpage ◆ Cracks ◆ Damage to sealing surface
7. Replacing Thermostat and Housing	7. Follow manufacturer's specifications. Be sure to check housing for damage when removing gasket. Replace coolant. Pressure-test system for leaks once new thermostat is in place and housing is reinstalled. Check thermostat for proper operation.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could discuss what happens when water freezes in an enclosed space like an engine block; how adding antifreeze and pressure affects the freezing and boiling points of water; and heat transfer principles (how to remove excess heat using air, a liquid, and fans).

Review:

Ask students review questions such as the following:

1. How can you determine whether the thermostat is installed correctly?
2. Why does the thermostat in the coolant system open and close?
3. What does the thermostat measure?
4. True or False: The thermostat is not needed and can be removed in warm weather.

Application:

1. Give students a teacher-prepared diagram of an engine cooling system, and have them diagram the flow of coolant twice (perhaps using different colors): once with the thermostat open, and once with the thermostat closed.
2. Provide students with a heater, a solution of antifreeze and water, a thermometer or pyrometer, and a thermostat, and have them heat the solution and note the temperature at two points: (a) when the thermostat begins to open, and (b) when the thermostat is fully open.
3. As students practice inspecting and testing the thermostat, by-pass, and housing, quiz them individually on the process (e.g., ask them to explain how to properly test the thermostat rating).

Evaluation:

√ Each student will inspect and test a thermostat, by-pass, and housing and replace them as needed. His/her performance will be evaluated using a copy of the performance checklist for Competencies 7.4.4/8.11.5.

Competencies 7.4.4/8.11.5: Inspect and test thermostat, by-pass, and housing; replace as needed

Performance Checklist

In inspecting and testing a thermostat, by-pass, and housing and replacing as needed, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Performed the following tests/checks in accordance with manufacturer's specifications:					
a. Cooling system pressure test	☐	☐	☐	☐	☐
b. Visual inspection of by-pass and housing	☐	☐	☐	☐	☐
c. Coolant temperature check	☐	☐	☐	☐	☐
5. Removed thermostat/housing in accordance with standard procedure	☐	☐	☐	☐	☐
6. Determined servicing or repair needed	☐	☐	☐	☐	☐
7. Reinstalled or replaced thermostat/housing in accordance with standard procedure	☐	☐	☐	☐	☐
8. Pressure-tested system for leaks	☐	☐	☐	☐	☐
9. Checked thermostat for proper operation	☐	☐	☐	☐	☐
10. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

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Competency 9.1: Utilize personal safety equipment

Competency Development Guide

Objective:

Condition: As part of all activities in the automotive shop
Behavior: Utilize personal safety equipment
Criteria: In accordance with the criteria in the checklist for Competency 9.1

Introduction:

General Introductory Techniques: Share personal experiences you have had concerning the use of personal safety equipment in the auto tech shop. Show videos that show various types of equipment and their use.

Competency-Specific Information:

1. Take an inventory. Have everyone count all their fingers, toes, and any other body parts that they have.
2. Announce that at the end of the year, this inventory will be repeated, and students are expected to come up with the same counts.
3. Explain to students that following all the rules for the use of personal safety equipment will help ensure that nothing will be missing in the end-of-the-year body parts inventory.

References:

OSHA 1920.130 series of Personal Protective Standards. (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling***. However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Eye and Ear Protection	1. Wear eye and ear protection in accordance with Occupational Safety and Health Administration (OSHA) standards. Wearing of safety glasses in vocational labs is also required by Ohio state law.
2. Foot and Hand Protection	2. Wear prescribed foot and hand protection. Wearing leather boots with nonskid soles and steel toes is optional. Protective gloves must be worn for working with solvents and welding.
3. Clothing	3. Wear clothing in accordance with OSHA standards. Wear no clothes that could get dragged into running machinery.
4. Jewelry	4. Remove jewelry in accordance with shop policy. Remember that a dangling earring or chain can get caught in moving machinery and cause serious injury.
5. Hair	5. Secure long hair (e.g., wear a cap or tie hair back) according to shop policy.
6. Lifting Techniques	6. Bend knees, not back. Get assistance for heavy loads. Use caution when twisting and lifting.

Presentation Outline	Steps to Cover/Key Points to Make
7. Personal Protective Equipment	7. Maintenance of personal protective equipment: • Clean protective equipment prior to and after each use. • Store protective equipment after each use so that it is not damaged. Student's responsibility for securing safety glasses

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied communications teacher can work with students in reading and interpreting OSHA standards.

Review:

Ask students review questions such as the following:

1. When should safety glasses be worn in the shop?
2. How should you lift heavy objects?
3. List some reasons why jewelry should be removed.
4. Identify three ways long hair could be shortened in a "shop experience."

Application:

1. Have students work in teams to develop safety posters, fliers, handbooks, etc., covering the use of personal safety equipment in the shop.
2. Ask students to perform an instructor- or school-prepared safety inspection of the entire automotive laboratory. (This should be done at ***least*** monthly and at random times.)

Evaluation:

√ Each student will utilize personal safety equipment. His/her performance will be evaluated using a copy of the performance checklist for Competency 9.1.

Competency 9.1: Utilize personal safety equipment

Performance Checklist

In utilizing personal safety equipment, the student—

	1	2	3	4	5
1. Selected/used correct equipment	☐	☐	☐	☐	☐
2. Wore eye and ear protection in accordance with OSHA standards	☐	☐	☐	☐	☐
3. Wore prescribed foot and hand protection	☐	☐	☐	☐	☐
4. Wore clothing in accordance with OSHA standards	☐	☐	☐	☐	☐
5. Removed jewelry in accordance with shop policy	☐	☐	☐	☐	☐
6. Secured long hair	☐	☐	☐	☐	☐
7. Practiced established lifting techniques	☐	☐	☐	☐	☐
8. Maintained personal protective equipment	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competency 9.2: Respond to fire situations

Competency Development Guide

Objective:

Condition: Given a series of written case studies and simulated situations
Behavior: Demonstrate knowledge of how to respond to fire situations *
Criteria: In accordance with the criteria in the checklist for Competency 9.2

Introduction:

General Introductory Techniques: Share personal experiences you have had with fire situations in the auto tech shop. Show videos that show fire situations, types of fires, proper responses, and/or use of fire extinguishers.

Competency-Specific Information:

1. In an emergency situation, action needs to be taken quickly. An emergency situation is not the time to develop such a plan.
2. Most auto shops have occasional fires, and part of your training is how to respond to a fire situation.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

* If local conditions allow, students may be able to witness (or even demonstrate actual responses to) fire situations. Check with local fire department or local fire training programs, and see if you can set up fire demonstrations. Make sure you check with the administration concerning insurance issues related to fire demonstrations.

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Fire Exits and Alarms	1. Locate all fire exits and alarms. Never place equipment in front of alarms and exits.
2. Evacuation Procedures	2. Importance of identifying established evacuation procedures for each facility in which you work Evacuation procedure for classroom/ shop Evacuation practice (drills) in accordance with specified procedure
3. Fire Blankets and First Aid Kits	3. Locate fire blankets and first aid kits. Ensure that first aid kit is kept fully stocked.
4. Types of Fires	4. Types of fires (e.g., chart/list of fire classifications available in textbook or through local fire department) Most common types of fires in automotive setting (gasoline, electric)
5. Fire Extinguisher Operation	5. Established procedures for using fire extinguishers ***Note:*** Most extinguishers require that you aim at base of fire.
6. Fire Extinguisher Maintenance	6. Established procedures for maintaining the operability of fire extinguishers Checking inspection stickers
7. Reporting Procedures	7. Follow established site-developed reporting procedures.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could explain how a fire "works" and how it is extinguished.

Review:

Ask students review questions such as the following:

1. Where should you go and how should you act in case of a fire in the classroom or shop?
2. What are the different types of fires? Which type of extinguisher should you use for each?

Application:

1. Give students a teacher-prepared shop diagram, and have them locate the position of all fire alarms, fire exits, fire extinguishers, first aid kits, and fire blankets.
2. Give students written case studies describing different types of fire situations, and have them select the correct type of extinguisher and correct overall response for each situation.
3. Have students participate in an evacuation drill.
4. Have each student orally explain the correct procedure for using a fire extinguisher.

Evaluation:

√ Each student will demonstrate knowledge of how to respond to fire situations. His/her performance will be evaluated using a copy of the performance checklist for Competency 9.2.

Competency 9.2: Respond to fire situations

Performance Checklist

In demonstrating knowledge of how to respond to fire situations, the student—

	1	2	3	4	5
1. Identified correct equipment for case situation	☐	☐	☐	☐	☐
2. Identified location of fire exits and alarms	☐	☐	☐	☐	☐
3. Followed established evacuation procedures	☐	☐	☐	☐	☐
4. Identified location of fire blankets and first-aid kits	☐	☐	☐	☐	☐
5. Identified types of fires	☐	☐	☐	☐	☐
6. Explained how to use fire extinguishers in accordance with established procedures	☐	☐	☐	☐	☐
7. Verified operability of fire extinguishers	☐	☐	☐	☐	☐
8. Explained established reporting procedures	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competency 9.3: Demonstrate general safety practices

Competency Development Guide

Objective:

Condition: As part of all activities in the auto shop
Behavior: Demonstrate general safety practices
Criteria: In accordance with the criteria in the checklist for Competency 9.3

Introduction:

General Introductory Techniques: Share personal experiences you have had related to general safety practices in the auto tech shop. Show videos that illustrate these practices.

Competency-Specific Information:

1. Introduce topic of safety through discussion of questions such as the following:
    - Who is responsible for your safety?
    - How can doing a job safely affect your company's profit?
    - How can ***not*** following safety rules affect those around you?

References:

OSHA Form 200 for reporting injuries and supplemental 101; OSHA "Job Hazard Analysis," Pamphlet 3071, 1988; OSHA "Lockout/Tagout Standard" (19 CFR 1910.47); and "Lifting It Right: A Safety Video for Automotive Lifts," Automotive Lift Institute. (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Shop Safety Practice Guidelines	1. Shop safety policies and procedures Importance of accepting responsibility for complying with shop safety plan Consequences of failure to comply with shop safety plan (physical and property damage that may occur)
2. Emergencies and Injuries	2. Facility emergency preparedness plan Facility requirements for responding to emergencies and injuries Procedure for reporting injuries to supervisor Procedure for completing written safety and injury reports: • Use of OSHA Form 200 and supplemental 101 Forms • Use of site-developed injury report
3. Jacking, Lifting, Moving, and Blocking Vehicles	3. Established procedures for jacking, lifting, moving, and blocking vehicles: • Industry-developed standard "Lift it Right" • Site-developed procedures Importance of checking brakes before moving vehicles Consequences of failure to check brakes Safe driving practices according to shop procedures; for example: • Go very slowly. • Make sure no one is standing behind or in front of vehicle. • Check that the brake pedal is not going to floor. • Don't drive over or on spilled liquids. Driver's license requirements Insurance requirements

Presentation Outline	Steps to Cover/Key Points to Make
4. Chains and Straps	4. Established procedures for using chains and straps; for example: ◆ Never use damaged chains/straps. ◆ Never stand in path or travel of chain or strap.
5. Hand Tools	5. Procedure for maintaining hand tools in safe operating condition Instances of dangerous hand tools; for example: ◆ Mushroomed chisels ◆ Greasy hammers ◆ Tools without handles or with loose handles ◆ Tools used for a purpose for which they were not designed
6. Shop Equipment	6. Equipment safety checks: ◆ Guards ◆ Shields ◆ Frayed electrical cords ◆ Bypassed switches
7. Defective Equipment	7. Lock-out/tag-out procedures for defective equipment: ◆ OSHA "Lockout/Tagout Standard" (19 CFR 1910.47) ◆ Site-developed guidelines
8. Working Conditions	8. Offenses that could result in unsafe working conditions leading to disciplinary actions (e.g., horseplay, substance abuse, theft) Site-developed consequences for the offenses

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied communications teacher could work with students on reading and interpreting established safety standards.

Review:

Ask students review questions such as the following:

1. List some consequences of not following safety instructions.
2. What are the rules for moving vehicles in the shop?
3. What are offenses that could get you in trouble, and what are the consequences of those offenses?
4. What should you check before moving a vehicle?

Application:

1. Have students practice skills in jacking, lifting, moving, and blocking vehicles.
2. Have students practice maintaining their own or assigned set of hand tools.
3. Describe an injury situation to students, and have them complete an injury report.
4. Give students written case studies describing injuries suffered by the instructor and other individual students, and ask them to explain what steps to take and procedures to follow in dealing with each injury.
5. Have students practice basic first aid.

Evaluation:

√ Each student will demonstrate general safety practices. His/her performance will be evaluated using a copy of the performance checklist for Competency 9.3.

Competency 9. 3: Demonstrate general safety practices

Performance Checklist

In demonstrating general safety practices, the student—

	1	2	3	4	5
1. Selected correct equipment to use	☐	☐	☐	☐	☐
2. Interpreted shop policy and procedures accurately	☐	☐	☐	☐	☐
3. Complied with shop safety plan	☐	☐	☐	☐	☐
4. Responded to emergencies and injuries in accordance with facility requirements	☐	☐	☐	☐	☐
5. Reported injuries to supervisor in accordance with established shop procedure	☐	☐	☐	☐	☐
6. Completed written safety and injury reports fully and correctly, using appropriate form or format	☐	☐	☐	☐	☐
7. Carried out all jacking, lifting, moving, and blocking of vehicles and shop equipment in accordance with established policies and procedures	☐	☐	☐	☐	☐
8. Checked brakes before moving vehicular equipment	☐	☐	☐	☐	☐
9. Demonstrated safe driving practices (following school policies)	☐	☐	☐	☐	☐
10. Used chains and straps in a safe manner	☐	☐	☐	☐	☐
11. Maintained hand tools in safe operating condition	☐	☐	☐	☐	☐
12. Maintained shop equipment in safe operating condition in accordance with manufacturers'/OSHA specifications	☐	☐	☐	☐	☐
13. Complied with lock-out/tag-out procedures for defective equipment	☐	☐	☐	☐	☐
14. Avoided offenses that could result in disciplinary action	☐	☐	☐	☐	☐
15. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competency 9.4: Maintain safe work environment

Competency Development Guide

Objective:

Condition:	As part of all activities in the automotive shop
Behavior:	Maintain a safe work environment
Criteria:	In accordance with the criteria in the checklist for Competency 9.4

Introduction:

General Introductory Techniques: Share personal experiences you have related to the safety of the work environment. Show videos that demonstrate how to maintain a safe work environment and/or consequences of an unsafe environment.

Competency-Specific Information:

1. 1994 OSHA Standard (29 CFR 1910, 1200) covers material safety data sheets (MSDSs) and employee's right to know.

2. Having a well-organized, clean, well-maintained, and well-lit shop is one good way to maintain a safe work environment.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Shop Cleanliness	1. Importance of maintaining clean work environment How to clean shop
2. Air Filtering and Ventilation	2. Environmental Protection Agency (EPA) regulations for air filtering and ventilation of the work environment General guidelines: • Local exhaust ventilation is best. • Hang hoses on vehicles even if for a short time. • Dilution ventilation may be required.
3. Sources of Contamination and Other Hazards (Identification/Containment)	3. Acute contamination Chronic contamination Air-borne contamination Other hazards (e.g., asbestos) Shop rags used to clean brake parts
4. Draining, Removal, and Storage of Gasoline Tanks	4. Established safety procedures (check with local fire department) Why a nearly empty tank may be more dangerous than a full one
5. Handling of Flammable Liquids	5. Established safety rules (e.g., store in spill-proof containers in nonflammable storage cabinet) ***Remember:*** Gasoline is more explosive than dynamite.

Presentation Outline	Steps to Cover/Key Points to Make
6. Storage, Use, Recycling, and Disposal of Hazardous Materials	6. Follow EPA regulations. Check with local fire department, which may have additional regulations. Analyze liability associated with hazardous material disposal. Responsibility does not end when the hazardous material leaves the site.
7. Hazardous Chemical Spills	7. Ohio ranks third in chemical accidents in the nation. Procedure for responding to hazardous chemical spills, including— • Keep material away from the drains. • If unsure, stay away. • Report per EPA guidelines. • Report to fire department if necessary.
8. Unsafe Practices and Conditions	8. Report unsafe practices and conditions. The instructor needs the eyes, ears, and noses of everyone in the shop. Correct unsafe practices and conditions. Don't leave spilled oil, gasoline, or antifreeze on the floor. Person responsible for spill should clean it
9. OSHA Right-to-Know Laws	9. Consumers have a right to information about— • product ingredients, when those ingredients are not a trade secret; and • any hazards, whether they are a trade secret or not. Hazard Communication Standard
10. Material Safety Data Sheets (MSDSs)	10. MSDSs identify the following: • Possible hazards when using the materials • Protective measures to take when using the materials • What to do if exposed to a material

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied communications teacher could work with students on documenting storage of hazardous materials and reading and interpreting MSDSs.

Review:

Ask students review questions such as the following:

1. Which is more explosive, a full gasoline tank or a nearly empty one? Why?
2. What is the difference between acute and chronic?
3. Do you have the right to know about hazardous materials if they are a trade secret? Explain your answer.
4. What is the difference between local and dilution ventilation? Which is best?
5. What is the best way to handle an oil spill?
6. When does responsibility end for a hazardous waste?

Application:

1. Give students a sample MSDS, and have them identify the hazards related to the chemical, protective measures to take when using it, and consequences of exposure to the chemical.
2. Give students written case studies describing situations involving different chemical spills, and have them explain how to respond to each in accordance with shop policy.
3. As students practice cleaning a vehicle stall, quiz them individually on the process (e.g., ask them how to select the appropriate cleaning supplies to use).

Evaluation:

√ Each student will maintain a safe work environment. His/her performance will be evaluated using a copy of the performance checklist for Competency 9.4.

Competency 9.4: Maintain safe work environment

Performance Checklist

In maintaining a safe work environment, the student—

	1	2	3	4	5
1. Selected correct equipment and supplies to use	☐	☐	☐	☐	☐
2. Followed TSB safety recommendations	☐	☐	☐	☐	☐
3. Maintained clean work environment	☐	☐	☐	☐	☐
4. Followed EPA regulations for air filtering and ventilation of the work environment	☐	☐	☐	☐	☐
5. Identified sources of contamination and other hazards	☐	☐	☐	☐	☐
6. Contained sources of air-borne contamination and other hazards (e.g., asbestos)	☐	☐	☐	☐	☐
7. Followed established safety procedures for the draining, removal, and storage of gasoline tanks	☐	☐	☐	☐	☐
8. Followed safety rules for handling flammable liquids	☐	☐	☐	☐	☐
9. Followed EPA regulations for the storage, use, recycling, and disposal of hazardous materials	☐	☐	☐	☐	☐
10. Analyzed the liability associated with hazardous material disposal	☐	☐	☐	☐	☐
11. Responded to hazardous chemical spills	☐	☐	☐	☐	☐
12. Reported unsafe practices and conditions	☐	☐	☐	☐	☐
13. Corrected unsafe practices and conditions	☐	☐	☐	☐	☐
14. Interpreted OSHA Right-to-Know law	☐	☐	☐	☐	☐
15. Interpreted material safety data sheets (MSDSs)	☐	☐	☐	☐	☐
16. Identified resources for employee's rights to information	☐	☐	☐	☐	☐
17. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competency 9.5:	Access needed information using available references and resources

Competency Development Guide

Objective:

Condition:	Provided with service references and resources
Behavior:	Access needed information
Criteria:	In accordance with the criteria in the checklist for Competency 9.5

Introduction:

General Introductory Techniques: Share personal experiences you have had when accessing needed information in the auto tech shop. Show videos that demonstrate the steps in this process.

Competency-Specific Information:

1. You can't work on today's vehicles without access to additional technical information. Your brain can't hold all the information you need.

2. In fact, you may find that the most common tool you use, after your brain, is some kind of service information tool—be it a manual or a computer.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Identifying Available Resources	1. Types and examples of each: • Manufacturer's specifications • Videos • Computer manuals • Service bulletins • Service manuals • Parts manuals • Company procedure manuals • Manufacturers' toll-free numbers • Internet sites • Estimating guides
2. Selecting Appropriate Resource for Given Task	2. When, where, and how each type of resource is used
3. Locating Information within Resource	3. How to find needed service information
4. Interpreting Information	4. How to read charts, graphs, schematics, illustrations, and tables

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied communications teacher could help students in locating and interpreting information and with their oral communication skills. The applied mathematics teacher could work with students on reading and interpreting graphs, charts, tables, etc.

Review:

Ask students review questions such as the following:

1. Name five different types of service information sources and how they are used.
2. What type of resource would you use to determine how to hook up vacuum hoses to an exhaust gas recirculation (EGR) valve?
3. What is the difference between a service bulletin and a service manual?

Application:

1. Give students a wiring diagram, and have them locate circuit numbers, wire colors, and possible problems in a circuit.
2. Give students access to technical service manuals, and have them locate the information necessary to replace a particular part (e.g., a head gasket) on a given vehicle.
3. Give students a chart and a particular symptom (e.g., an automatic transmission that won't shift into high or reverse), and have them use the chart to diagnose where the problem could be.
4. Have students locate five sites on the Internet that contain service information.

Evaluation:

√ Each student will access needed information using available references and resources. His/her performance will be evaluated using a copy of the performance checklist for Competency 9.5.

Competency 9.5: Access needed information using available references and resources

Performance Checklist

In accessing needed information using available references and resources, the student—

	1	2	3	4	5
1. Identified available resources	☐	☐	☐	☐	☐
2. Selected appropriate reference materials and resources for each given task	☐	☐	☐	☐	☐
3. Located needed information within each given reference or resource	☐	☐	☐	☐	☐
4. Correctly interpreted text material	☐	☐	☐	☐	☐
5. Correctly interpreted materials provided in chart form	☐	☐	☐	☐	☐
6. Correctly interpreted materials provided in graph form	☐	☐	☐	☐	☐
7. Correctly interpreted materials provided in table form	☐	☐	☐	☐	☐
8. Correctly interpreted materials provided in illustrations	☐	☐	☐	☐	☐
9. Correctly interpreted materials provided in schematics	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name_______________________________________**Date**______________

Competency 9.6: Demonstrate use of basic tools

Competency Development Guide

Objective:

Condition: Provided with a set of basic tools
Behavior: Demonstrate use of basic tools
Criteria: In accordance with the criteria in the checklist for Competency 9.6

Introduction:

General Introductory Techniques: Share personal experiences you have had when using basic tools in the auto tech shop. Show videos that show basic tools and their uses.

Competency-Specific Information:

1. Basic hand tool use is a learned art form. The tools you buy to work with are an expensive investment and should be treated as such. As professional technicians, poor habits concerning the maintenance and use of your tools will cost you in safety, in productivity, and in dollars. Ask yourselves, is it worth doing it correctly?

2. In this lesson (or lessons), you will get a general overview of the types of tools used by auto technicians, their names and characteristics, and—perhaps most important—basic safety and maintenance (cleaning/storage) procedures. Then, throughout the program, we will spend more time on the correct and safe use and proper maintenance of individual hand tools as they are used in performing specific tasks.

References:

Technical service bulletins (TSBs); tool lists in the NATEF document, *ASE Certification for Automobile Training Programs*. (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Applicable Safe Practices	1. Follow standard safe practices (e.g., use of safety glasses; proper footwear; hair. restrained; no loose clothing or jewelry).
2. Tools and Their Uses	2. Types and examples of each (see NATEF list)
3. Selecting Appropriate Tool for Given Task	3. When, where, and how to use each tool
4. Measurements (English & Metric)	4. How to measure— • Inside diameter • Outside diameter • Lift • End-play • Run-out • Backlash

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher can help with basic math functions and measurements (metric and English).

Review:

Ask students review questions such as the following:

1. What is the difference between the metric system and the old American system of measurement?
2. What is the difference between a feeler gauge and a dial indicator?
3. On a thousandths scale micrometer, how many different numbers will you be adding and what are their scales?

Application:

1. Give students a box of bolts, and have them measure the bolts with a ruler.
2. Give students a box of bolts, and have them measure both the diameter and the head of the bolts with a micrometer.
3. Have students inventory a toolbox.
4. Write wrench sizes on board. See which student can get a box of wrenches to match the board order first.

Evaluation:

√ Each student will demonstrate use of basic tools. His/her performance will be evaluated using a copy of the performance checklist for Competency 9.6.

Competency 9.6: Demonstrate use of basic tools

Performance Checklist

In demonstrating use of basic tools, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
3. Performed basic math functions accurately	☐	☐	☐	☐	☐
4. Demonstrated knowledge of tools and their uses	☐	☐	☐	☐	☐
5. Selected tool appropriate for each given task	☐	☐	☐	☐	☐
6. Applied metric and English measurement skills	☐	☐	☐	☐	☐
7. Accurately measured inside/outside diameters	☐	☐	☐	☐	☐
8. Accurately measured lift	☐	☐	☐	☐	☐
9. Accurately measured end-play	☐	☐	☐	☐	☐
10. Accurately measured run-out	☐	☐	☐	☐	☐
11. Accurately measured backlash	☐	☐	☐	☐	☐
12. Maintained orderly work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competency 9.7: Provide customer service

Competency Development Guide

Objective:

Condition:	Provided with a customer (or someone role-playing a customer) with a vehicle and a service order
Behavior:	Provide customer service
Criteria:	In accordance with the criteria in the checklist for Competency 9.7

Introduction:

General Introductory Techniques: Share personal experiences you have had when providing customer service in the auto tech shop. Show videos which demonstrate the steps in this process and/or which illustrate typical customer service situations.

Competency-Specific Information:

1. Who pays your wages? Ultimately in the automotive service industry, it is the customer.

2. How important is it to keep customers happy? If customers are dissatisfied, the shop you work for may go out of business and take your job with it.

References:

Technical service bulletins (TSBs); "Ohio Consumer Sales Act and Substantive Rules," Attorney General, State of Ohio (pamphlet). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Note: The content in this Competency Development Guide can be very much enhanced by inviting 1–3 service advisors and/or shop owners in to talk with the students about customer service. This provides students with some real-world examples from folks who are out there dealing with it every day.

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Applicable Safe Practices	1. Follow standard safe practices (e.g., use of safety glasses; proper footwear; hair. restrained; no loose clothing or jewelry).
2. Service Order	2. How to prepare service orders with customer input Importance of including odometer reading, phone number where customer can be reached, and customer's signature
3. Diagnosis	3. Guidelines for communicating solutions to customers Difference between a "suggested repair" and a "required repair" How to prepare an estimate Ohio law: over $25, an estimate is required. Informing customer if there is a charge for preparing estimate
4. VIN Codes	4. Location of vehicle identification number (VIN) codes Interpretation of VIN codes (e.g., tenth digit refers to model year, eighth digit refers to engine)
5. Documenting Service	5. Importance of transferring technician information to clean customer copy R & R, R & I, etc. Importance of readability (e.g., legible writing, accurate spelling)

Presentation Outline	Steps to Cover/Key Points to Make
6. Completing Service/Work Orders	6. Importance of math skills and accuracy Costs of parts Labor/Flat Rate Sales tax Procedure for completing service/work orders
7. Consumer Rights	7. Customer has right to written estimate prior to start of work. All old parts must be returned to customer. All work must be authorized with a signature. Attorney General, State of Ohio, has written guidelines in pamphlet form.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied communications teacher can help students with filling out service and work orders accurately and clearly, with correct spelling.

Review:

Ask students review questions such as the following:

1. Where are the VIN codes located on a vehicle?
2. What is the difference between a "suggested repair" and a "required repair"?
3. What does R & R mean? What does R & I mean?
4. What must be done with the old parts?
5. What form must be completed before you are legally allowed to repair a vehicle?

Application:

1. Provide pairs of students with repair problems, and have one student role-play the service advisor and one student role-play the customer. The service advisor's task is to prepare a service order with customer input and communicate solutions to the customer.
2. Have students identify the year of all model vehicles in the shop by VIN codes.
3. Provide students with parts cost, labor cost, and tax rate, and have them total a repair order.
4. Provide students with a flat rate manual, typical labor jobs, and a labor rate per hour, and have them calculate labor costs.

Evaluation:

√ Each student will provide customer service. His/her performance will be evaluated using a copy of the performance checklist for Competency 9.7.

Competency 9.7: Provide customer service

Performance Checklist

In providing customer service, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Prepared service orders with customer input	☐	☐	☐	☐	☐
3. Communicated solutions to customers clearly	☐	☐	☐	☐	☐
4. Located vehicle identification number (VIN) codes	☐	☐	☐	☐	☐
5. Identified needed information about vehicle from VIN codes	☐	☐	☐	☐	☐
6. Documented services recommended and performed	☐	☐	☐	☐	☐
7. Calculated costs accurately	☐	☐	☐	☐	☐
8. Ensured readability of documentation (e.g., legible writing, accurate spelling)	☐	☐	☐	☐	☐
9. Complied with consumer rights guidelines	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name_______________________________________**Date**_____________

Competency 9.8: Acquire parts

Competency Development Guide

Objective:

Condition: Provided with a parts request
Behavior: Acquire parts
Criteria: In accordance with the criteria in the checklist for Competency 9.8

Introduction:

General Introductory Techniques: Share personal experiences you have had when acquiring parts in the auto tech shop. Show videos that demonstrate the steps in this process.

Competency-Specific Information:

1. Parts don't just miraculously appear. They have to be ordered.
2. Ask students for examples from their own experience in which a car couldn't be driven because a needed part didn't arrive for a long time or the part wasn't right.
3. It is the technician's responsibility to ensure that the parts person gets the correct information and that the part received for the vehicle is correct.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Background Information	1. All necessary information must be available before picking up phone to contact parts person. Collect necessary information (e.g., make, model, year, VIN, option codes): • Location and meaning of VIN codes • Production plate on vehicle
2. Conveying Information to Parts Person	2. Telephone contact procedures (e.g., stating who you are, the company you represent, why you are calling) Telephone answering procedures (e.g., "Hello," "Thank you for calling," "How may I help you?")
3. Checking Price	3. Price used must be within customer estimate guidelines.
4. Checking Availability	4. Is the part available? If not, how long will it take to arrive?
5. Confirming Order on Receipt	5. Confirm that part received is the correct one. If using delivery driver, confirm correct part before driver leaves.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied communications teacher can work with students on communicating clearly, efficiently, and courteously via the telephone.

Review:

Ask students review questions such as the following:

1. What must you know before you pick up the phone to order a part?
2. Why is it necessary to ask for parts availability when ordering parts?
3. What must you do if the price of the part is greater than the estimate provided to the customer?

Application:

1. Provide pairs of students with a parts catalog, and have them role-play phone contacts, with one student playing the role of parts person and one student playing the role of technician seeking parts information.
2. ***With permission*** from local parts suppliers, allow students to call for "estimates" on vehicles they diagnose in the laboratory. Ask them to record all prices, quantities, part numbers, etc., on given repair estimate form.

Evaluation:

√ Each student will acquire parts. His/her performance will be evaluated using a copy of the performance checklist for Competency 9.8.

Competency 9.8: Acquire parts

Performance Checklist

In acquiring parts, the student—

	1	2	3	4	5
1. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
2. Collected all necessary information (e.g., make, model, year, VIN, option codes)	☐	☐	☐	☐	☐
3. Conveyed information to parts person clearly and accurately	☐	☐	☐	☐	☐
4. Verified that price was within estimate guidelines	☐	☐	☐	☐	☐
5. Verified availability of part	☐	☐	☐	☐	☐
6. Confirmed that the correct part was received	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name_______________________________________**Date**_____________

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Competency 10.2: Inspect vehicle components and systems

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Perform safety inspection of vehicle components and systems
Criteria:	In accordance with the criteria in the checklist for Competency 10.2

Introduction:

General Introductory Techniques: Share personal experiences you have had when inspecting vehicle components and systems in the auto tech shop. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Ask students how performing safety inspections on vehicles benefits the technician.
2. Ask them how performing safety inspections on vehicles benefits the customer.

References:

Technical service bulletins (TSBs). (See listings of standard references for the field, pp. 12–15, and auto-related Websites, pp. 6–10, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 15, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Applicable Safe Practices	1. Follow standard safe practices (e.g., use of safety glasses; proper footwear; hair. restrained; no loose clothing or jewelry).
2. Inspection Process	2. Procedure for checking each of the following as part of a safety inspection: ◆ Vehicle warning lights ◆ Vehicle tires (air pressure, tread) ◆ Hoses and belts ◆ Exhaust system ◆ Filters (fuel, air, oil) ◆ Brake system ◆ Steering linkages ◆ Coolant system ◆ Fluid condition and levels (oil, antifreeze, rear-end lube, transmission fluid, power steering fluid, brake fluid) ◆ Leaks from engine, transmission, brake lines, and rear-end differential ◆ Exterior lights ◆ Seat belts ◆ Wipers and washers ◆ Exterior and interior condition of vehicle (body damage; wheel cover condition; integrity of glass, hinges, locks, and handles)

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied communications teacher can work with students on using reference books to find, evaluate, and synthesize information.

Review:

Ask students review questions such as the following:

1. In what ways do inspections benefit an owner's vehicle?
2. What specific safety-related items should you inspect for on a customer's vehicle?

Application:

1. Give students a fluid replacement booklet, and have them determine what type of fluid a certain transmission, radiator, and engine should use.
2. As students practice inspecting vehicle components and systems, quiz them individually on the process (e.g., ask them what they found that needed to be repaired, or how much money this repair could save the customer in the long run).

Evaluation:

√ Each student will perform a safety inspection of vehicle components and systems. His/her performance will be evaluated using a copy of the performance checklist for Competency 10.2.

Competency 10.2: Inspect vehicle components and systems

Performance Checklist

In performing a safety inspection of vehicle components and systems, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Analyzed condition of all undercar systems in accordance with standard inspection procedures	☐	☐	☐	☐	☐
5. Accurately identified any problems in the following undercover systems:					
a. Tires	☐	☐	☐	☐	☐
b. Exhaust system	☐	☐	☐	☐	☐
c. Brakes	☐	☐	☐	☐	☐
d. Steering	☐	☐	☐	☐	☐
6. Analyzed condition of all underhood systems in accordance with standard safety inspection procedures	☐	☐	☐	☐	☐
7. Accurately identified any problems in the following underhood systems:					
a. Belts and hoses	☐	☐	☐	☐	☐
b. Filters	☐	☐	☐	☐	☐
c. Coolant system	☐	☐	☐	☐	☐
d. Fluids (condition, levels, leaks)	☐	☐	☐	☐	☐
8. Analyzed interior/exterior condition of specific vehicle components in accordance with standard inspection procedures	☐	☐	☐	☐	☐

	1	2	3	4	5
9. Accurately identified any problems in the interior/exterior condition of the following components:					
a. Warning lights	☐	☐	☐	☐	☐
b. Exterior lights	☐	☐	☐	☐	☐
c. Seat belts	☐	☐	☐	☐	☐
d. Washer/wiper system	☐	☐	☐	☐	☐
e. Auto body, glass, hinges, locks, and handles	☐	☐	☐	☐	☐
10. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

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